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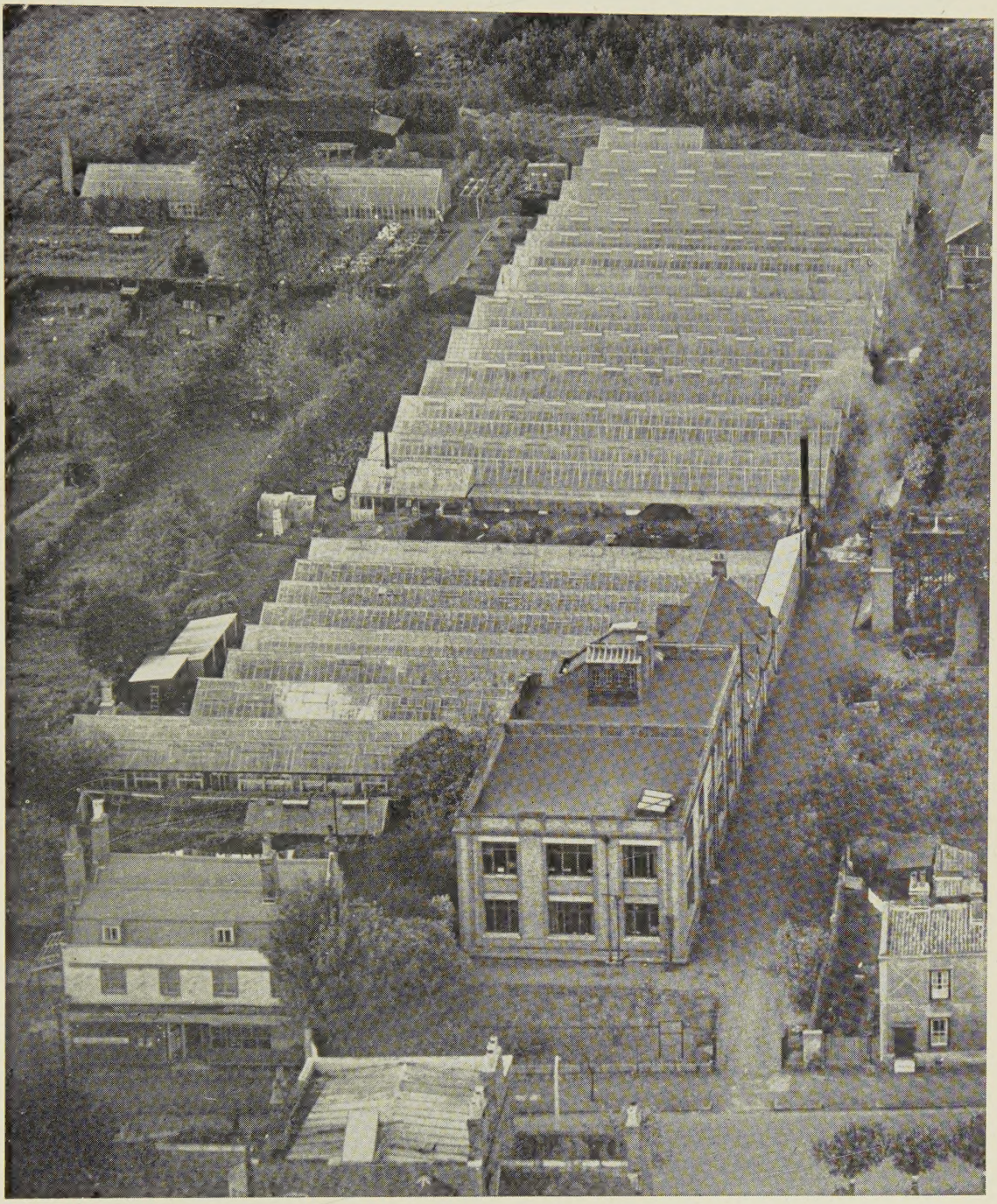

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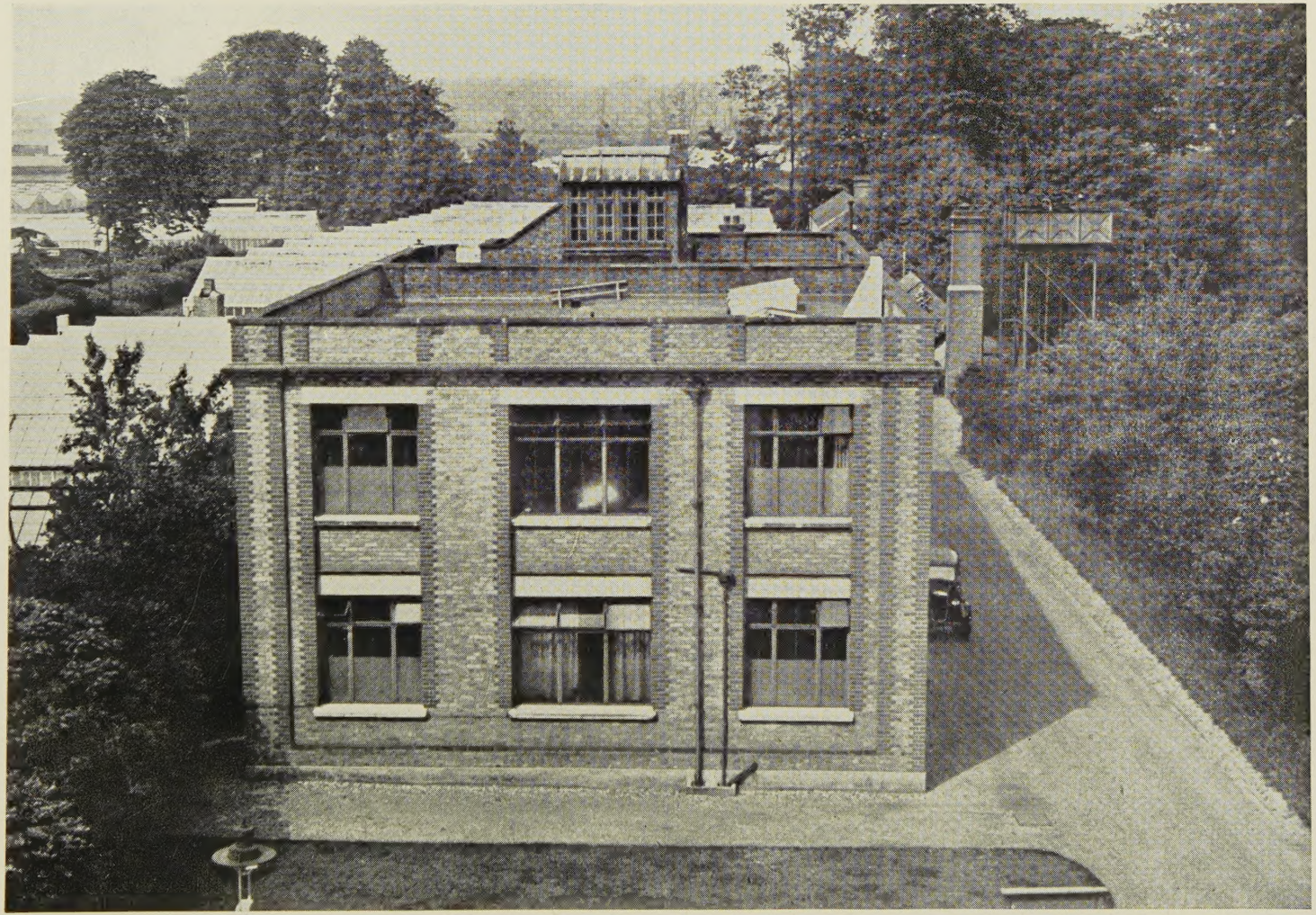

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Diagram showing arrangements of Experimental Plots in 1950.

INTRODUCTION

It is a pleasure to record that the work of all departments is making steady progress, although it is being retarded considerably by the congested state of the laboratories. The leaky and unstable condition of the glasshouses, resulting from enemy action during the war period, is most unsatisfactory and the continual repairs are a constant source of expense.

Current Investigations

The investigation of the effect of certain forms of seaweed and alginic acid on the growth of tomatoes was continued in large-scale experiments in house 10. Comparisons were made between horse manure, milled seaweed both before and after extraction, and also sodium alginate.

As in 1949 milled seaweed had no effect upon the yield of the tomato, neither had the same material after commercial extraction of the alginates, etc. In 1949 and previous years the addition of sodium alginate seemed to increase the crop, but this year there was no difference between the control plots and those receiving sodium alginate. It is interesting to record that L.M.R. 1, the variety used in this experiment, gave the relatively satisfactory yield of 50 tons per acre, despite the fact that its high quality fruit are sometimes of a small size.

The experiment started in 1947 to determine the effect of omitting lime and phosphate from the tomato fertilizer treatment was continued for the fourth year. The experimental results give no indication that the omission of lime and phosphates has had any effect upon the crop, which averaged approximately 50 tons per acre.

The cropping power of plants raised in soil blocks was compared with those from size 60 pots. There was no difference in total yield obtained, but the plants from soil blocks produced 0·68 lbs. per plant more in June than those from pots This is not surprising, because after they have been planted, young plants raised in soil blocks, establish themselves in the surrounding soil very quickly, whereas those planted from pots are almost invariably checked in growth for about a week, while new roots are forming on the outside of the ball of soil.

An experiment was arranged in house 8, where four plots were sterilized with steam and four with chloropicrin. The high yield of 65 tons per acre was obtained but there was no significant difference between the different plots. This is an extremely interesting result for it reveals chloropicrin as a most useful soil sterilizing agent equal in this particular case to steam. Unfortunately Chloropicrin is extremely difficult to obtain in view of the world situation and next year we must be content to repeat the experiment using "DD" instead of chloropicrin.

Some interesting preliminary results were obtained this year, when Potentate was grafted on certain strong root-producing varieties, namely E.S.1, E.S.5, B.R.1, and Bides Recruit. The yield produced varied according to the stock used, E.S.5 giving the highest yield of 54·8 tons per acre.

In the cucumber houses, an excellent control of root-knot eelworm, *Heterodera marioni*, was obtained by first sterilizing the soil with steam and then injecting it with either chloropicrin or "DD." For the first time for many years, the crops were almost free from infection with the eelworm. Bees still continued to cause damage by "setting" the fruits, and finally we had to cover the ventilators with coarse hessian to keep them out. Good results were obtained by placing 6-in. drainpipes or a core of brushwood in the centre of the beds. This not only reduces the amount of horse manure used, but gave a slightly higher yield.

In the mushroom experiments deep beds (10 ins.) produced 2·72 pounds of marketable mushrooms per sq. ft. against 1·5 lbs. per sq. ft. from the control.

The addition of 28 lbs. of castor meal per ton of manure also increased the yield from 1·5 lbs. to 1·94 lbs. per sq. ft. In other experiments the addition of either stones or sand to the casing soil increased the crop.

During an investigation of the effect of soil conditions on the growth and survival of *Didymella lycopersici* in pure culture, it was found that the fungus continued to grow over a wide range of moisture content. Growth was best at 50 per cent. saturation and much less at 100 per cent. It was very slight at 15 per cent., but survived for six months at all moisture levels.

There was a rapid fall in the number of colonies isolated from infected soil when the temperature was raised to 27° C.

Investigations concerning the fungal flora of tomato roots have been continued. Isolations made from roots which had been growing in steam-sterilized soil show quantitative and some qualitative differences when compared with those made previously from roots in unsteamed soil. The microflora of the root surface and rhizosphere soil was found to differ from the root microflora and from that of soil more distant from roots.

Inoculation experiments suggest, so far, that of the fungi isolated only *Colletotrichum atramentarium* is actively parasitic on tomato roots, although other fungi may adversely affect the growth of plants.

Spraying with 1 per cent. tannic acid in water to control the spread of tomato mosaic by contact was shown neither to affect the taste of the fruit nor the crop yield. Negligible amounts of deposit remained on the fruit. Measures for protecting the eyes and hands of tomato workers are suggested. In a small trial 50 per cent. reduction in spread of tomato (aucuba) mosaic was obtained by spraying with the above solution. Sulphonated lorol did not inhibit the viricidal property of 1 per cent. tannic acid and is a useful wetting agent for this substance.

The virus content of tomato seeds infected with tomato mosaic virus was reduced considerably by heat treatment: there was little effect on the seed itself. Heat treatment of Arum Lily corms infected with spotted wilt virus was attempted. There was some destruction of virus but no control.

Watering the soil of potted plants with malachite green solution reduced symptoms of both tomato aucuba mosaic and potato virus X. This action of malachite green had been recorded previously by Stoddard and Dimond in the case of tomato mosaic.

The Gladiolus Thrips was recorded for the first time in the British Isles (and Europe) on a market garden at Edmonton, Middlesex, in July. Subsequently the pest was found to be present in a number of other localities in England.

The occurrence of the insect was announced at the meeting of the Royal Entomological Society of London at its meeting on September 6th, and an account will shortly be published in the Proceedings of that Society. The life-history, habits, and measures for control of the pest are described briefly, with illustrations, under "Growers Notes."

Owing to a sudden and almost complete disappearance of Tomato Leaf-miner in glasshouses, sufficient material for the purpose of further study did not become available.

Studies upon British Thysanoptera have been continued. Species in the genera Rhipidothrips, and Melanthrips are dealt with.

The examination of the toxicities of certain compounds to the red spider mite (*Tetranychus telarius* L.) has been continued. In ovicide trials with certain phenyltrichloromethylcarbinols and their esters the *para*-chlorine substituted compound was found to be most active. The acetic esters were appreciably less toxic and the benzoic, *para*-chlorobenzoic and *para*-nitro-benzoic esters much less toxic than the parent carbinols. None of the compounds were sufficiently toxic to be of practical ovicidal value in the control of this pest.

A number of recently discovered acaricides, some of which appear suitable for aerosol application, have been examined both in the laboratory and in preliminary glasshouse trials.

The laboratory investigation of the fungicidal properties of quinones has been continued and their phytotoxicities examined in spraying trials on tomatoes.

The effect of external conditions on ammonification and nitrification in soil after steam sterilization has been investigated further. Soil which had been steam sterilized in the experimental houses in November, 1949, has been sampled *in situ*. Bulk samples from the same plots were taken immediately after steaming and stored in earthenware pots covered with glass plates and maintained at 23·5° C. in a dark incubator. The contents of the pots were sampled at the same time as the soils in the glasshouse. Ammonification and nitrification have been followed under both conditions. In all cases ammonification was stimulated initially and nitrification suppressed. In the incubated steamed soils the ammonia concentration rose to a maximum and then fell to a low level again after a few weeks, its disappearance being accompanied by rapid nitrification. After the initial rapid increase the ammonia concentration in the soils in the glasshouse, however, persisted at a high level

for several months after steaming. For example, in incubated soil the ammonia concentration had risen and subsequently fallen to a low level in 51 days, whereas in the glasshouse it was still high at 49·5 p.p.m. 135 days after steaming.

This striking difference in the course of ammonification and nitrification under the two sets of conditions may be due to several causes, of which either contamination or aeration of the incubated soil during sampling appear most likely. At each sampling the incubated soils were turned out on to paper, mixed and sufficient taken for analysis, thus exposing the soil to possible contamination for approximately two minutes at every sampling. To prevent contamination 50—100 gms. of soil were partially sterilized in plugged flasks and subsequently incubated undisturbed until analysis. Here the ammonia concentration increased to a maximum rapidly and remained at a high level, nitrification being inhibited. The similarity between this result and that obtaining in the glasshouse may suggest that the undisturbed soil in the house is not readily contaminated by nitrifying organisms. This view is substantiated by the fact that deliberate contamination of sterilized soil in flasks with an infusion of the original untreated soils causes a rapid decline of the ammonia concentration accompanied by nitrification. Thus in the case of a cucumber soil contamination resulted in the ammonia concentration rising and then falling to a low level again in 38 days, whereas in the uncontaminated soil (to which was added an equivalent amount of distilled water) the ammonia concentration was still high at 30·5 p.p.m. after 129 days.

The sampling also entails thorough mixing of the soils during which they are brought into intimate contact with the atmosphere whereas in the glasshouse there is little aeration in the main bulk of the soil.

Preliminary attempts at aeration in the laboratory were unsuccessful owing to the rapidity of drying out of the steamed soil when aerated, the difficulty of eliminating contamination, and sampling difficulties under these conditions.

Further study of contamination of soil after steaming with unsteamed soil has shown that this invariably hastens the fall in ammonia concentration accompanied by rapid nitrification compared with the changes ensuing in the steamed soil alone.

The effect of varying the time of steaming on ammonia production has also been investigated. It was found that increased initial ammonia concentration, probably due to thermal decomposition of soil nitrogen, is proportional to the time of steaming. This is also true for subsequent ammonia production provided steaming has not been so prolonged as to render the soil sterile. Thus in a cucumber soil it was found that increasing the time of steaming up to one hour increased the subsequent ammonification, but after steaming for two hours there was no subsequent production after the initial increase in ammonia.

The decomposition of 17 amino acids has been studied by mixing them with soil and incubating at 23·5° C., analysis for ammonia and nitrate being made at frequent intervals. In two such experiments high (negative) correlation coefficients were obtained for percentage conversion to ammonia and to nitrate respectively.

Tests on 16 samples designated as bone meal, with particular reference to their nitrogenous constituents, showed that wide variations exist between samples from different sources. Total nitrogen values ranged from 2·12 per cent. to 5·55 per cent. Of the total nitrogen between 1 per cent. and 50 per cent. was soluble in water in the different samples. This wide variation in soluble nitrogen was significantly correlated with ammonia and nitrate formation after incubation in soil for nine days. Significant correlations were also obtained between the result of the soil densities of the samples after milling through a 1 mm. screen, pH of their aqueous suspensions, and the ammonia liberated on distillation with magnesia. The effect of different degrees of milling upon the results of the tests was also examined for selected samples, and it was shown that bone materials are markedly heterogeneous with respect to total and water-soluble nitrogen.

Published research in America suggested the possibilities of urea-formaldehyde compounds as nitrogenous fertilisers, and preliminary soil tests were made with a sample kindly supplied by Imperial Chemical Industries. We have since prepared and tested a number of urea-formaldehyde compounds, using molar ratios of urea to formaldehyde of from 1 to 3.

An important chlorosis of glasshouse roses is being investigated. Symptoms of the disorder conforms to descriptions of those of manganese deficiency and qualitative tissue analysis confirmed this. Qualitative work indicates that the deficiency is induced by excessive amounts of calcium in the soil. Attempts to correct the condition by spraying with manganese sulphate solution have been unsuccessful either because no correction has taken place, or else scorching of the foliage and flowers

has occurred. Promising results have been obtained on the commercial scale by dressing the borders with flowers of sulphur.

The study of the effects of acute mineral deficiencies on chrysanthemums has been confined to the elements boron, manganese and potassium, but the number of varieties used was extended to 14. The main conclusions to be drawn from the work are that the effects of any deficiency depend on the time the deficiency begins to operate in the life history of the plant and any one deficiency is liable to produce different effects in different varieties.

It appears that the "Deminrolit" water treatment leaves the water near the critical level of concentration of boron. Where solutions were made up in such water mild symptoms of boron deficiency occurred but later disappeared. Where, however, this water was replaced by distilled water symptoms of boron deficiency became acute within 14 days. The effects of boron deficiency on the flowers reported last year have been confirmed. The shape, texture and conformation of the petals are all profoundly affected. With the white reflexed Edith Alston, for instance, the omission of boron causes the petals to curl and their surfaces to become dull and rough, almost corrugated, in comparison with the smooth sheen of the normal petals. There was little reduction in the diameter of the complete flower, but under the treatment it became incurved. In the case of the white incurved flower the effects on individual petals were the same, but the size of the complete bloom was reduced and the petals were packed more tightly into the centre. Another important point of difference is seen when petals are bruised. In the absence of boron an injury due to bruising becomes brown in a matter of minutes. In the presence of boron, however, the seat of injury remains grey and apparently transparent. The effects on foliage varied in different varieties, but always there was a considerable shortening of the internodes and usually some chlorosis.

Difference in varietal susceptibilities is well shown in the two white varieties Monument and Autocrat. Both show the same symptoms when deprived of boron but react quite differently to a deficiency of manganese. In the latter case, little effect is shown in the rate of growth of Monument whereas Autocrat under the same conditions is appreciably stunted. Similarly a deficiency of potassium operating early in the life of the plant has a decidedly retarding effect on growth generally, but the actual effects on leaves of different varieties vary considerably.

Observations have been continued on air and soil temperatures under Dutch lights and in the open in collaboration with the Agricultural Branch of the Meteorological Office. The frames have been moved to a new site alongside the new meteorological station plot. This economises in the number of thermometers and gives a better exposure. As a result of the longer exposures to sunlight in the absence of early morning shading, higher temperatures have been observed under the lights. The data obtained have been analysed and it is evident that in order to elucidate the factors involved in the "protection" afforded (i.e. difference in temperature under glass and in the open) recording instruments are required.

Further soil-block surveys of tomato roots in glasshouse borders have been made. These indicate very heterogeneous distribution especially in the upper layers where subdivision into shallower blocks was made.

Estimations of soil atmosphere in a tomato border were made through the growing season at different depths and distances from the plant and through cycles of watering and drying out. Comparison was made with the atmosphere in adjacent soil containing no plants. These observations will need to be related to root growth studies.

The standard gauge-model soil tensiometer was again tried out in a tomato border for comparison with laboratory types made up of filter candles and mercury manometers. These show more rapid response to the cycle of wetting and drying of the soil.

Meteorological records have been taken since 1916 with an increased number of observations since 1928 and published as a summary in the Annual Report. At the beginning of 1950 the meteorological plot was transferred from the site south of the space between the cucumber houses and No. 1 tomato house (shown in aerial photograph of the Research Station) to the southern end of the "standing-out" ground, east of the Rose House. Owing to the restricted space available and the numerous adjacent buildings, trees and hedges this site still does not correspond to the standard requirements of a meteorological plot but the exposure is considerably better and may be regarded as fairly typical of the climate of the Lea Valley. As such it has been approved by the Meteorological Office as a Crop Weather Station and a set of standard instruments has been supplied. The meteorological observer attended a short course for crop weather observers. Our thanks are due to the authorities for these facilities. Some alterations have been made in the annual summary of Meteorological Records.

EXPERIMENTAL RESULTS OF 1950

1. TOMATOES

The practice of grading the tomato fruits from the experimental plots, adopted in 1921, was continued:—

A. "Pinks" number 5 to 7 and "Pink and White" 8 to 10 to the lb. These are the best quality of fruit in size, shape and colour; "Pinks" being slightly larger than "Pink and Whites."
B. "Whites." These fruits are of good colour but smaller than "Pink and White."
C. "Blues." This grade consists of fruits of good colour but larger and more irregular in shape than Grade A.
D. "Roughs." Small mis-shapen fruits about the size of cherries.
E. Blotchy fruits which ripen irregularly.
F. Fruits showing Blossom End Rot.
G. Fruits showing the lesions of Streak Disease.
H. Fruits showing "Green Back."

(a) House 3

In house 3 the experiment was in four parts. In two plots plants of E.S.5 were planted from size 60 pots. In two others plants from 60's were set out on the top of soil ridges, 6 ins. high. In two plots the young plants had been raised in soil blocks, while in the last two plots the soil blocks were stood on the surface of the ground and soil was drawn up towards them, instead of planting in the orthodox manner. All plants started well, and the cropping results were practically the same for each treatment except where plants from "60" pots were planted on ridges. Here the yield was significantly lower. The results are given in Table I.

(b) House 4

In house 4, the deficiency plots reacted in the usual way, the omission of potash giving rise to 40 per cent. blotchy fruit, nitrogen 14 per cent. and phosphates only 3 per cent.

In four small plots 5a—5d, scions of Potentate were grafted upon stocks of E.S.1, E.S.5, B.R.1, and Bides Recruit. These were chosen because they all produce strong persistent roots. The grafts were made without difficulty and the plants grew strongly, the strength increasing from E.S.1 to E.S.5, Bides Recruit and B.R.1 in that order. The resulting yields were 45.6 tons per acre on E.S.1, 54·8 on E.S.5, 50·8 on B.R.I, and 51·8 on Bides Recruit. The experiment will be repeated in 1951. The results are given in Table II.

(c) House 8: Steam sterilization versus chloropicrin

An interesting experiment was carried out in house 8, where four plots were steam sterilized and four were treated with chloropicrin. The latter was applied at the rate of 400 lbs. per acre under W. H. Read's supervision on December 15th, making the injections 6 ins. deep at intervals of 12 ins. As in the cucumber houses, the soil surface was soaked by watering lightly to wet only the top half-inch of soil.

The results given in Table III record a high yield, and there was no significant difference between the two treatments, suggesting that chloropicrin may prove to be a valuable soil sterilizing compound. Examination of the roots at the end of the season revealed only slight infection by the root-knot eelworm, *Heterodera marioni*.

(d) House 9. Pots versus soil blocks

In this house there were four equal plots all planted with the variety Ailsa Craig.

Two plots were planted with young plants raised in soil blocks and two with plants from size 60 pots. Total yields, see Table IV, were practically identical, but during the month of June 0·68 lbs. per plant more were picked from the soil block plants than from those raised in pots. This is explained by the fact that plants taken from "60" pots usually suffer a check of about seven days after planting out, whereas the roots of soil block plants grow on immediately into the surrounding soil.

TABLE I

VARIETY E.S.5. SOIL STERILIZED WITH FORMALDEHYDE

House	Plot	Treatment	Crop Yield in Lbs. per Plant						Total Tons per Acre	Average Tons per Acre	% Blotchy Ripening
			May	June	July	Aug.	Sept.	Total			
3	1	Planted from 3-in. pots (60's)	0·24	1·69	1·60	1·02	0·56	5·11	38·84	37·62	0·78
	5	,, ,, ,, ,, ,, ...	0·17	1·58	1·45	1·07	0·52	4·79	36·40		0·83
3	2	Planted in soil blocks	0·23	1·70	1·71	1·29	0·59	5·52	41·95	38·87	1·09
	3	,, ,, ,, ,, ...	0·19	1·53	1·51	1·04	0·44	4·71	35·79		1·70
3	6	Planted from 3-in. pots on to soil ridges	0·29	1·60	1·33	0·91	0·41	4·54	34·50	33·55	0·89
	8	,, ,, ,, ,, ,, ,, ,, ,,	0·19	1·59	1·51	0·59	0·41	4·29	32·60		0·46
3	4	Soil blocks. Stood on soil and earthed up	0·17	1·50	1·80	1·03	0·61	5·11	38·82	37·09	0·98
	7	,, ,, ,, ,, ,, ,, ,, ,,	0·19	1·44	1·54	1·06	0·42	4·65	35·34		

TABLE II

VARIETY E.S.1. SOIL STERILIZED BY STEAM

House	Plot	Treatment	Crop Yield in Lbs. per Plant							Total Tons per Acre	% Blotchy Ripening
			May	June	July	Aug.	Sept.	Oct.	Total		
4	1	Complete artificials without nitrogen ...	0·40	1·86	0·50	0·58	0·18	0·09	3·61	27·44	2·48
	2	Unmanured	0·15	1·70	0·74	0·32	0·14	0·04	3·09	23·48	13·92
	3	Complete artificials	0·08	1·58	2·38	1·44	0·55	0·17	6·20	47·12	2·90
	9	,, ,, with dung	0·13	1·43	1·99	1·17	0·41	0·16	5·29	40·20	1·71
	10	,, ,, without phosphates ...	0·23	1·98	1·84	0·83	0·59	0·21	5·68	43·17	2·65
	11	,, ,, ,, potash ...	0·23	1·11	1·75	0·77	0·35	0·21	4·42	33·59	40·29
4	4	Leather waste, bone meal and potash ...	0·10	1·69	2·38	1·73	0·47	0·16	6·53	49·63	3·82
	8	,, ,, ,, ,, ,, ,, ...	1·14	1·45	1·87	1·40	0·64	0·19	5·69	43·24	1·40
	5a	Potentate grafted on E.S.1	—	0·69	2·23	1·64	0·62	0·82	6·00	45·60	3·34
	5b	,, ,, ,, E.S.5	—	0·73	2·98	1·49	1·37	0·65	7·22	54·87	9·15
	5c	,, ,, ,, B.R.1	—	0·74	2·65	1·37	1·43	0·50	6·69	50·84	9·57
	5d	,, ,, ,, Bides Recruit ...	—	0·65	3·05	1·85	0·65	0·62	6·82	51·83	10·99

TABLE III

VARIETY POTENTATE

House	Plot	Treatment	Crop Yield in Lbs. per Plant								Total Tons per Acre	Average Tons per Acre	% Blotchy Ripening
			May	June	July	Aug.	Sept.	Oct.	Nov.	Total			
8	1	Steam sterilization...	0·13	2·49	2·00	1·70	2·42	0·80	0·41	9·95	75·62	65·87	5·22
	4	„ ...	0·01	2·49	1·68	1·96	1·86	0·53	0·26	8·79	66·80		6·39
	6	„ „ ...	—	1·35	1·97	1·31	2·03	0·86	0·40	7·92	60·19		9·21
	7	„ „ ...	0·62	1·34	1·85	1·19	1·93	0·98	0·70	8·01	60·87		8·98
8	2	Chloropicrin... ...	0·11	1·91	2·01	1·77	2·18	1·01	0·44	9·43	71·66	65·38	6·25
	3	„	0·06	2·20	1·74	1·65	2·04	0·74	0·33	8·76	66·57		8·35
	5	„	—	1·40	1·81	1·68	2·21	0·80	0·30	8·20	62·32		8·17
	8	„	0·05	1·57	1·87	1·40	2·02	0·64	0·47	8·02	60·95		6·99

TABLE IV

VARIETY: AILSA CRAIG. SOIL STEAM STERILIZED.

House	Plot	Treatment	Crop Yield in Lbs. per Plant							Total Tons per Acre	Average Tons per Acre	% Blotchy Ripening
			June	July	Aug.	Sept.	Oct.	Nov.	Total			
9	2	Planted from size 60 pots ...	1·29	2·10	2·63	1·95	1·04	0·52	9·53	72·42	69·16	3·06
	4	„ „ „ „ ...	1·07	2·01	2·44	1·75	1·00	0·40	8·67	65·89		2·77
	1	Planted from soil blocks ...	1·46	1·98	2·15	1·85	0·85	0·58	8·87	67·41	66·88	1·58
	3	„ „ „ „ ...	1·58	1·30	2·05	1·86	1·23	0·71	8·73	66·35		1·43

(e) House 10. Seaweed substances

House 10 was devoted to an experiment with seaweed substances. Two plots were dressed with milled seaweed (2 lbs. per sq. ft.), two with the same material after extraction (2 lbs. per sq. ft.) and two with sodium alginate (1 lb. per sq. ft.). There were two control plots, one receiving 7 lbs. of stable manure per sq. yd. and one without stable manure. The results given in Table V show no significance difference in yield between the different plots.

This may be explained by the fact that the variety L.M.R. 1 does not require heavy dressings of either nitrogen or stable manure, and also that the soil had been sterilized by steaming. It is interesting to note that L.M.R. 1, a small fruited good quality tomato, has produced the satisfactory yield of 50 tons per acre.

(f) Houses 11 and 12. The effect of omitting lime and phosphate from the fertiliser treatment

These experiments commenced in 1947 have been continued in this their fourth year. The results given in Table VI do not show any appreciable reduction in yield as the result of omitting lime and/or phosphates, a yield of approximately 50 tons per acre being produced.

(g) Variety trials

The variety trials were continued in the rose house. Two varieties developed severe symptoms of mosaic disease early in the season and owing to labour difficulties it spread rapidly through the house. Although the yield averaged rather more than 50 tons per acre, the results are unreliable and are therefore omitted from this report.

2. CUCUMBERS

Although the crop of saleable cucumbers in our glasshouses (1·51 flats per ft.) is a little higher than it was in 1949 (1·34 flats per ft.) it is still on the low side and once more this is due to invasion of the houses by bees and the consequent fertilisation of the fruits. It is calculated that the injury resulting from this cause amounted to not less than 0·5 flats per ft. Added to the 1·5 flats per ft. of saleable fruit a total of 2 flats per ft. is obtained. This is a reasonably good crop and shows that the methods of cultivation employed are satisfactory.

The most interesting result of this year's experiments has been the effect of both chloropicrin and "D.D." upon the root knot eelworm (*Heterodera marioni*). The cucumber houses have been badly infected with this eelworm for many years because despite annual steam sterilization of the soil, it has persisted in the neighbourhood of the walls and hot water pipes and spread outwards during the growing season, particularly at the ends of the houses.

In preparation for the 1950 crop, all the houses were steam sterilized in October, 1950. Later, November 17th–19th, houses D, E and G were treated with "D.D." and house F with chloropicrin, under the supervision of W. H. Read. The soil was very dry at the time of treatment. The dosage in each case was at the rate of 12 lbs. per house or approximately 400 lbs. per acre. Injections were made every 12 ins. to a depth of 8 ins. and the borders were sealed by watering lightly to wet the top half-inch of soil. The whole of the houses were treated, including the paths, and special care was taken to see that the soil in contact with the brickwork (walls and piers) was treated adequately.

Each house contained 96 plants. The roots were lifted carefully at the end of the crop. All were free from eelworm attack, except one slightly infected plant in house D, and six in house F.

There was no evidence suggesting an increase in crop as the result of these treatments, but the freedom from eelworm at the end of the season was quite outstanding.

In house D, the crop from standard raised beds (2 parts loam and 1 part horse manure) was compared with that from a flat bed in a shallow brick trough. There was a slight reduction in yield in the latter. In another plot a new apparatus for "drip" watering was tested. The plants grew well, but the crop was rather lower than in the control plots. The apparatus will be used again in 1951.

In house E a line of 6-in. drainpipes formed the centre of some beds. In one plot the ends of the line were open to the air, in another they were closed. In still another plot a core of brushwood was placed in the middle of the bed. The three plots produced about 70 tons per acre, which was a little higher than the control of 62 tons per acre. This confirms the results of 1950.

Top dressings of magnesium sulphate house F had no effect on the plants. In house G, however, some yellowing of the foliage appeared in plots 3 and 5 where composted straw was used. The plants

TABLE V

VARIETY: L.M.R. No. 1. SOIL STEAM STERILIZED.

House	Plot	Treatment	Crop Yield in Lbs. per Plant							Total Tons per Acre	Average Tons per Acre	% Blotchy Fruit
			June	July	Aug.	Sept.	Oct.	Nov.	Total			
10	3	Control with stable manure ...	0·39	1·49	1·42	1·63	1·26	0·73	6·92	51·83		7·33
	8	,, without stable manure	0·46	1·80	1·51	1·79	0·94	0·33	6·83	51·90		4·39
	2	Milled Seaweed	0·54	1·55	1·23	1·31	1·05	0·86	6·54	49·70	51·64	6·26
	4	,, ,, ...	0·23	1·53	1·74	1·47	1·12	0·96	7·05	53·58		7·36
	1	,, ,, after extraction	0·43	1·69	1·46	1·50	1·20	0·82	7·10	53·96	50·69	4·93
	5	,, ,, ,, ,,	0·19	1·33	1·51	1·26	1·08	0·87	6·24	47·42		8·65
	6	Sodium alginate	0·19	1·50	1·39	1·57	1·20	0·65	6·50	49·40	49·67	6·01
	7	,, ,, ...	0·18	1·58	1·41	1·76	0·99	0·75	6·67	49·93		3·20

TABLE VI

VARIETIES: PLOTS 1 AND 4 E.S.1; PLOTS 2 AND 3 L.M.R. No. 1. SOIL STEAM STERILIZED

House	Plot	Treatment	Crop Yield in Lbs. per Plant								Total Tons per Acre	Average Tons per Acre	% Blotchy Fruit
			May	June	July	Aug.	Sept.	Oct.	Nov.	Total			
11	1	Standard treatment...	0·06	1·33	1·68	2·18	1·27	0·29	0·12	6·93	52·66	52·32	3·17
	2	,, ,, ...	0·01	0·89	1·15	2·07	1·52	0·86	0·34	6·84	51·98		4·10
	3	No lime	—	0·59	1·23	1·47	1·22	0·59	0·35	5·45	41·42	43·13	3·67
	4	,, ,, ...	0·01	1·14	1·29	1·70	1·25	0·27	0·24	5·90	44·84		1·18
12	1	No phosphates ...	0·15	1·91	1·57	1·37	1·17	0·20	—	6·37	48·41	49·55	2·67
	2	,, ,, ...	0·01	1·76	1·36	1·56	1·23	0·75	—	6·67	50·69		7·79
	3	No phosphates and no lime	0·04	1·47	1·54	1·49	1·05	0·81	—	6·40	48·56	51·87	5·01
	4	Ditto	0·14	1·81	2·06	1·92	1·23	—	—	7·26	55·17		3·99

TABLE VII

VARIETY: BUTCHER'S DISEASE RESISTER

Plot	Treatment		Crop Yield in Lbs. per Plant								Total Tons per Acre	Average Tons per Acre	Total Flats per Ft.	Average Flats per Ft.
	Base	Beds	Apr.	May	June	July	Aug.	Sept.	Oct.	Total				
D2	"DD"*	Control	7·17	12·12	9·08	8·62	4·02	10·45	1·25	52·71	79·06	79·61	1·65	1·66
D3	,,	,, ...	7·99	12·26	9·49	9·37	3·42	9·23	1·68	53·44	80·16		1·67	
D4	,,	Planted in a shallow brick trough	7·17	10·08	7·99	9·21	2·87	9·41	1·97	48·70	73·05		1·53	
D5	,,	Drip watering system ...	7·41	11·57	7·80	7·21	3·27	10·88	1·74	49·88	74·82		1·56	
E2	,,	Control	7·26	10·61	8·26	5·78	2·70	6·11	0·54	41·26	61·89		1·29	
E3	,,	6-in. drain pipes in bed; ends open	6·62	11·34	9·81	7·31	3·08	8·25	0·62	47·03	70·54		1·47	
E5	,,	6-in. drain pipes in bed: ends closed	7·70	11·50	8·61	6·92	3·40	8·05	0·69	46·87	70·30		1·46	
E4	,,	Brushwood core in beds ...	7·68	11·45	8·19	7·96	3·32	7·04	0·85	46·49	69·73		1·45	
E6	,,	Plants trained under Gutter into adjoining house ...	3·69	11·13	9·94	8·13	5·35	6·56	1·06	45·86	68·79	61·94	1·43	1·29
F1	Chloropicrin	Plants trained under gutter into adjoining house ...	4·05	8·40	8·24	4·39	5·22	5·59	0·84	36·73	55·09		1·15	
F3	,,	Standard beds: Control ...	7·81	11·79	9·67	5·81	4·79	7·47	0·67	48·01	72·01		1·50	
F5	,,	,, ,, ,, ...	8·12	11·42	9·85	6·13	3·21	10·01	1·49	50·23	75·34	73·79	1·57	1·54
F6	,,	,, ,, ,, ...	6·84	10·77	10·33	7·55	4·39	8·63	0·85	49·36	74·04		1·55	
F2	,,	Top-dressed with magnesium sulphate ...	6·93	9·55	9·29	5·14	3·87	5·19	0·77	40·74	61·11	63·94	1·28	1·33
F4	,,	Top-dressed with magnesium sulphate ...	7·21	10·84	8·48	6·82	4·67	5·91	0·59	44·52	66·78		1·39	
G2	"DD"	Standard treatment: Control	6·01	11·53	12·66	8·11	3·22	14·77	1·06	57·36	86·04	86·02	1·80	1·80
G4	,,	Standard treatment: Control	5·96	10·27	10·56	9·08	5·05	14·06	2·36	57·34	86·01		1·80	
G1	,,	Main laterals and sub-laterals turned downwards	6·94	10·54	11·83	8·18	2·59	11·28	1·99	53·35	80·02		1·57	
G3	,,	Straw composed with sulphate of ammonia and lime	5·14	9·97	11·03	7·15	3·24	12·65	0·77	49·95	74·92		1·57	
G5	,,	Composed by Adco process	5·93	9·48	9·79	7·13	2·47	12·17	2·96	49·93	74·89		1·57	

* Chemical treatment after steaming.

recovered a normal colour after two dressings of magnesium sulphate at the rate of 2 ozs. per yd. run of bed.

In past years composted straw has always proved as good as stable manure in the preparation of the beds. This year there was a reduction in yield, the cause of which has not been ascertained. The results are given in Table VII.

3. MUSHROOMS

1. Depth of bed

In view of the continual discussion regarding the effect of the depth of the bed upon crop yield, standard beds 7 ins. deep were compared with beds 10 ins. deep. The results were definitely in favour of the deep beds, for the average yield of caps as prepared for market was 2·72 lbs. per sq. ft. from the deep beds and 1·50 lbs. per sq. ft. from the control beds. See Table VIII.

TABLE VIII

Compost	Casing Soil	Total Caps* per Sq. Ft.	
Stable manure: bed 7 ins. deep... ...	Sterilised soil + 2% lime	1·50	
,, ,, ,, ,, ,, ...	,, ,, ,, ,,	1·48	1·50
,, ,, ,, ,, ,, ...	,, ,, ,, ,,	1·53	
,, ,, ,,10 ins. ,, ...	,, ,, ,, ,,	2·72	
,, ,, Castor meal (28 lbs. per ton) added	,, ,, ,, ,,	1·94	

* Stalks not included in these figures—only caps as sent to market.

TABLE IX

Compost	Casing Soil	Total Caps per Sq. Ft.
Stable manure	Sterilised soil with 2% lime	1·81
,, ,, ...	Stones only	0·75
,, ,, ...	,, 1, soil 1	2·13
,, ,, ...	,, 1, ,, 3	1·44
,, ,, ...	Peat 1, soil 1	1·81
,, ,, ...	,, 3, ,, 1	1·00
,, ,, ...	Sand 3, soil 1	1·88
,, ,, ...	,, 1, ,, 1	2·06
,, ,, ...	Vermiculite	0·75
,, ,, ...	,, 1, soil 1	1·80
,, ,, ...	,, 1, ,, 3	1·80

2. Castor meal

In previous experiments the addition of various kinds of oil cake to horse manure in the process of composting has almost invariably increased the yield of mushrooms. A trial was made this year with castor meal, applied at the rate of 28 lbs. per ton at the first turning. The average yield was increased from 1·50 lbs. in the control bed to 1·94 lbs. per sq. ft. where castor meal had been added. Table VIII.

3. Artificial casing mixtures

A series of mixtures of soil with stones, sand, peat and vermiculite, etc., were used for casing the beds, the resulting crop yields being compared with that from the standard sterilized soil casing mixture. The results are given in Table IX.

It is interesting to note that the crop yield was only increased by the mixtures of equal parts of stones and soil, and sand and soil respectively.

Increasing the amount of soil in either mixture led to a reduction in crop.

II. PLANT DISEASES

1. DIDYMELLA INVESTIGATIONS

By P. H. WILLIAMS

During 1950 investigations have been continued on the effect of soil conditions on the growth and survival of *Didymella lycopersici.*

(a) Soil moisture

Air-dry soil was weighed out in 300 g. lots into 500 ml. flasks. The flasks were divided into five series in which the soil moisture was adjusted to 15 per cent., 30 per cent., 50 per cent., 75 per cent., and 100 per cent. saturation respectively. They were sterilized in the autoclave, inoculated by adding 3 ml. of a spore suspension derived from a pure culture of the fungus and incubated on the bench in the laboratory. Samples of the soil were plated three, five, seven and 26 weeks after inoculation. The results are shown in Table I.

TABLE I

NUMBER OF *Didymella* COLONIES IN THOUSANDS PER G. OF DRY SOIL IN SOIL OF VARYING MOISTURE CONTENT

Time Weeks	Moisture Content (per cent. of saturation)				
	100	75	50	30	15
3	14	241	307	376	0
5	68	800	2314	225	0
7	218	1624	1565	510	0
26	67	452	590	177	4

In the early stages growth was best at 30 per cent. saturation but later at 50 to 75 per cent., which corresponds to a moisture content of 33 to 42 per cent. on an oven dry basis. The fungus can therefore grow in soils with a wide range of water content although in very dry soil growth is very slow. When free from the competition of other fungi it can also remain viable for at least six months.

(b) Temperature and survival

In 1944, Read inoculated the borders in a cucumber house with *D. lycopersici* during the course of his work on fungicides. Tomatoes were planted and a large proportion of them became infected. In the spring of 1945 the house was used for propagating cucumbers and maintained at a temperature of 65–70° F. for about nine weeks. A second crop of tomatoes was planted later in the borders but none became infected. The disappearance of the fungus may well have been due to the warm, moist condition of the soil during the propagation of the cucumbers and experiments have been carried out this year to test this possibility.

Flasks of soil were prepared as above, the moisture content being adjusted to 50 per cent. saturation. After inoculation, they were incubated on the bench for five weeks and then subjected to various temperatures. Five flasks were placed in an incubator at 80° F., five were kept at 61° F. and five in the refrigerator at 40° F. A flask from each series was removed at intervals of four weeks and samples of the soil plated. The results are given in Table II.

TABLE II

NUMBER OF *Didymella* COLONIES IN THOUSANDS PER G. OF DRY SOIL IN SOIL KEPT AT VARIOUS TEMPERATURES

Time (Weeks)	Temperature ° F.		
	80	61	40
4	60	2,037	1,618
8	3	424	1,817
12	1	1,264	1,386
16	0	589	962
20	3	659	—

The number of colonies in the series kept at 80° F. was consistently much lower than in the others. The flasks kept at 40° F. appeared to maintain their numbers rather better than those kept at 61° F.

A more comprehensive experiment was then carried out in which the effect of increasing the soil moisture was also studied. The inoculated flasks were incubated on the laboratory bench for five weeks. At this stage samples from six flasks were plated to obtain the number of colonies present at the beginning of treatment. Sufficient water was then added to half the flasks to bring the moisture content to saturation. Four flasks at 50 per cent. and four at 100 per cent. saturation were then placed at 80° F., 61° F., and 40° F. as before. Samples were plated at intervals of four weeks and the results are given in Table III. The numbers at the beginning of treatment were 9,720,000 per g. of dry soil.

TABLE III

NUMBER OF *Didymella* COLONIES IN THOUSANDS PER G. OF DRY SOIL IN SOILS KEPT AT VARIOUS TEMPERATURES AND AT 50 PER CENT. AND 100 PER CENT. SATURATION

Time (Weeks)	80° F.		61° F.		40° F.	
	100%	50%	100%	50%	100%	50%
4	41	17	10,775	9,797	18,006	9,679
8	111	16	10,786	5,941	13,080	6,732
12	66	2	10,943	6,801	18,838	7,900
16	112	3	878	11,051	16,524	9,377

Again there was a very striking fall in the number of colonies from flasks kept at 80° F. Nevertheless, the fungus was not completely killed for some weeks, suggesting that some of the mycelium was more resistant to adverse conditions. In culture, *D. lycopersici* forms a varying proportion of dark brown swollen hyphæ. It is possible that these hyphæ are formed to a certain extent in soil and are responsible for the survival of the fungus under unfavourable conditions.

High soil moisture favoured the survival of *D. lycopersici* in an active condition and at low temperatures led to large increase in the amount of the fungus in the soil. From this it may be supposed that under natural conditions, the fungus may not only survive through the winter on diseased tomato stems but may even increase in amount. Whether this will occur or not will depend on the amount and nature of the competition by other organisms which will vary according to circumstances. It is, however, another argument in favour of the destruction of all diseased plant material at the end of the season.

From these experiments it appears probable that the disappearance of *Didymella* from the soil of the cucumber house during the winter of 1944–45 was due to the comparatively high temperatures during the propagation of cucumbers. Recent observations have shown that the soil temperature at a depth of about 6 ins. may reach 65° to 70° F. Experiments are in progress to determine more exactly the effect of temperature in the range from 61° to 80° F., and also how long the fungus can survive under adverse temperature conditions.

(c) The effect of size of soil particles

Previous work[1] suggested that the fungus did not penetrate very deeply into the soil, being mainly confined to the outer layers where air was more abundant. It seemed possible that if the amount of pore space were increased by using soil of larger particle size the fungus would penetrate more deeply into the soil and higher counts would result.

Accordingly, a quantity of air-dry soil was sifted first through a 6-mm. sieve and then through a 3 mm. In this way soils of two particle sizes were obtained, 3–6 mm. and less than 3 mm. Flasks were prepared by the usual procedure from each, the moisture content being adjusted to 50 per cent. saturation. After inoculation, they were incubated at laboratory temperature and samples plated at intervals. The results are shown in Table IV.

Contrary to expectation, the numbers in the fine soil were consistently higher than in the coarse. Possibly the surface of the larger particles tended to dry out, thus limiting fungal growth. The results suggest that an open, dry surface soil might prevent the fungus establishing itself from air-borne infection.

TABLE IV

NUMBER OF *Didymella* COLONIES IN THOUSANDS PER G. OF DRY SOIL WHEN GROWN IN SOILS OF DIFFERING PARTICLE SIZE

Weeks	3–6 mm.	0–3 mm.
3	462	1,398
7	5,537	9,238
11	4,467	9,573
15	3,565	5,887
19	2,731	4,912

(d) The effect of steaming on growth and survival

A previous experiment[2] has shown that *D. lycopersici* can survive in both steamed and unsteamed soil for 16 weeks. Further experiments have been carried out this year.

In one experiment flasks of soil were prepared in the usual manner, the moisture content being adjusted to 50 per cent. saturation. Half the flasks were then sterilized in the autoclave, a modified procedure being used which was not so drastic as the usual method. The remainder were left untreated. After inoculation with a spore suspension, the flasks were incubated on the laboratory bench.

Unfortunately, the soil was so heavily contaminated with *Penicillium* sp. that the *Didymella* was crowded out in plates from the unsteamed soil. Although the primary purpose of the experiment had failed, it was carried on in order to see how long *D. lycopersici* would persist in the steamed soil. It was found possible to re-isolate it 41 weeks after inoculation.

In a second experiment 10-in. pots were filled with a mixture of 9 parts maiden loam and 1 of stable manure. The contents of half of them was then steamed in a small steaming apparatus in the laboratory. Cultures of *D. lycopersici* on sand and oatmeal were mixed with the soil which was then returned to the pots. The remainder of the pots received similar treatment except that the soil was not steamed. The pots were covered with brown paper and stored in the laboratory. Periodically they were weighed and sufficient water added to keep the moisture content of the soil at its original level.

After a preliminary incubation period of eight weeks, one pot from each series was removed at intervals of four weeks and the contents mixed thoroughly. Tomato plants variety Potentate were potted into size 32 pots, an inch being left at the top which was filled with the soil to be tested. Ten plants were used to test each soil. The plants were examined for disease after five weeks.

By this method, it was found that the fungus was alive and capable of infecting tomato plants 43 weeks after mixing the cultures with both steamed and unsteamed soil. Out of nine experiments, the fungus in steamed soil gave a higher proportion of infected plants than the unsteamed in six. This suggests that the fungus grew rather more freely in steamed than in unsteamed soil, but the differences in most cases were too small to warrant any definite conclusion.

(e) Growth in steamed soil and susceptibility to infection

It has been suggested that plants growing in steamed soil are more susceptible to infection than those in unsteamed. An attempt to test this was made this year by growing plants in steamed and unsteamed soil in 10-in. pots.

A suitable potting compost was prepared and sufficient to fill five large pots was steamed in the laboratory. After steaming, the soil was put into pots which had been previously sterilized by autoclaving. At the same time five pots were filled with unsteamed compost. Tomato plants variety Potentate were then planted in the pots. At the time of potting, small glass tubes 1·5 in. long and 1 in. in diameter were inserted in the soil about 2 ins. from the stems. Four weeks later the plants were inoculated by pouring 100 mls. of spore suspension into the soil by means of the tubes. The latter were then withdrawn and the holes filled in with steamed or unsteamed soil in the appropriate cases. Six weeks later the plants were examined for disease and it was found that three plants in the steamed soil and two in the unsteamed were infected. No difference was noted in the appearance of the plants and it is probable that if any effect on susceptibility to infection is produced by steaming the soil, pot culture is not a suitable method for demonstrating it.

(f) Depth of inoculation

Two experiments were carried out to see if the depth at which the inoculum was introduced into the soil would influence infection. It seemed probable in view of earlier work on the growth of

the fungus in flasks that it did not penetrate very deeply into the soil. Conversely, it seemed possible that the fungus, if buried deeply enough in the soil, would not be able to grow out to the surface. To test this assumption, glass tubes 1 in. in diameter were inserted in the soil when potting plants in 10-in. pots. In one series of five they were 4 ins. long and in a second 2 ins. and in both they were about 3 ins. from the plant. In a third series they were omitted. Three weeks after potting, the plants were inoculated by pouring 100 mls. of spore suspension into each tube, taking care that none overflowed on to the soil. The tubes were then withdrawn and the holes filled with soil. In the third series the spore suspension was poured on to the surface of the soil. Eight weeks later, all the plants where the spores had been buried 4 ins. deep were healthy while all those where they had been buried 2 ins. deep or poured on the surface were diseased.

The experiment was repeated later in the year, but in this case while five out of five surface inoculated plants became infected, four out of five became diseased in each of the series in which the spores had been buried. It is possible that the lower temperatures prevailing in the autumn were more favourable to the growth of the fungus so that it was able to reach the plant.

These experiments will be repeated in the coming season.

References

[1] Williams, P. H., Rep. Exp. Res. Sta., Cheshunt, 1949, p. 25.

[2] Williams, P. H., *ibid.*, p. 26.

2. BROWN ROOT ROT OF THE TOMATO

By P. H. WILLIAMS and MARION EBBEN

The investigations of the fungal flora associated with tomato roots have been continued. This year roots from plants grown in steamed soil in the border have been examined, and the fungal species isolated compared with those previously isolated from unsteamed soil. The same plot in House 7 was used after steaming during the autumn of 1949 and the methods employed in the examination of the roots were the same as those previously reported.

The general appearance of the roots on steamed soil presented some striking differences from those previously examined. Throughout the year the fibrous root systems of the plants were better developed and although small brown lesions occurred frequently on some of the smaller roots, they were less severe and extensive than on roots from unsteamed soil. The most noticeable improvement on steamed soil was the later and less widespread occurrence of roots infected with *Colletotrichum atramentarium*. On unsteamed soil, roots infected with this fungus could be identified with the naked eye at the beginning of June, and from then on were abundant. On steamed soil, the sclerotia were not seen on the roots until the middle of July, although the fungus had been isolated a few times from root tissue in June. While the fungus occurred regularly during the remainder of the season, it affected only a small proportion of the roots. The swollen corky roots, described on unsteamed soil as occurring regularly from July onwards, were not found until the end of September and the few plants examined after this date showed only slight development of this type of lesion. The brown cortical lesions at the stem base and upper part of the tap root were first seen in May and occurred frequently during the following months, but were usually only slightly developed.

Isolations of fungi were made chiefly from lesion tissue but also from some healthy looking roots as in the previous year. Most of the species isolated have been recorded before from unsteamed soil, and only four new species were isolated. Three of these, *Verticillium albo-atrum*, *Thielavoipsis basicola* and *Cylindrocarpon radicicola*, have been described from various sources as occurring in tomato root lesions and in these investigations they were isolated very rarely. In the case of the *Verticillium* isolates the infected plant did not show any symptoms of wilt disease. The other fungus which had not been isolated previously was found only once from lesion tissue during May and was identified by Mr. S. J. Hughes of the Commonwealth Mycological Institute as *Gelasinospora* sp.

The isolates made from roots in steamed soil represented growth from 27·7 per cent. of the root pieces placed on agar slopes as compared with 73·4 per cent. from roots on unsteamed soil, the numbers of fungi isolated each month also being correspondingly lower. The most commonly isolated fungi were *Fusarium* spp., *Colletotrichum atramentarium*, *Chaetomium cochliodes* and some less readily fruiting species of *Chaetomium*, the grey sterile fungus "K" and *Volutella ciliata*. A few isolations of *Petriella asymmetrica* were also recorded. These species had all been isolated from roots before, but on steamed soil the numbers of the different fungi differed from those on unsteamed soil as is shown in Table I.

TABLE I

FUNGI AS PERCENTAGE OF TOTAL ISOLATED

	C. atramentarium	*Chaetomium* spp.	*Fusarium* spp.	*Volutella ciliata*	"K"	*P. asymmetrica*
Unsteamed soil ...	28·0	14·7	19·4	8·6	22·1	6·3
Steamed soil ...	19·5	13·2	33·0	12·5	12·8	1·5

The distribution of the different species throughout the year is shown together with that for unsteamed soil in Table II. *Chaetomium* spp. again became less frequent as *Colletotrichum* increased, and isolates of *Fusarium* spp. and *V. ciliata* varied, but were usually higher from roots on steamed soil. The fungus "K" both decreased in number and was not recorded till later in the season on steamed soil, and *P. asymmetrica* also occurred less frequently.

TABLE II

PERCENTAGE DISTRIBUTION OF FUNGI THROUGHOUT THE SEASON

		Mar.	April	May	June	July	Aug.	Sept.	Oct.
C. atramentarium	U* ...	—	—	5	20	42	23	49	50
	S* ...	—	—	—	20	32	18	22	6
Chaetomium spp.	U ...	30	38	22	4	5	6	5	4
	S ...	20	29	22	—	5	5	43	6
Fusarium spp.	U ...	16	24	18	42	10	30	13	15
	S ...	—	—	35	10	24	29	20	65
"K"	U ...	19	9	28	26	25	23	20	15
	S ...	—	—	—	30	20	14	11	16
V. ciliata	U ...	3	9	9	—	14	13	5	8
	S ...	80	8	12	10	12	19	—	5
P. asymmetrica	U ...	30	9	15	—	3	2	1	—
	S ...	—	8	—	10	3	—	—	—

U* — Unsteamed soil

S* — Steamed soil.

The most marked change is the fall in the numbers of isolations of *Colletotrichum* and "K", which might be expected from observations on the general state of the roots, since as described above *Colletotrichum* symptoms were reduced and the corky roots, from which the highest proportion of "K" isolates were made, were fewer on steamed soil.

The higher proportion of *Fusarium* spp. and *V. ciliata* suggests that these fungi tend to predominate in the root microflora when more active pathogens or saprophytes are absent. In Table III a more detailed comparison of the percentage of different genera isolated from different lesion types is given.

TABLE III

PERCENTAGE OF FUNGI ISOLATED FROM DIFFERENT LESION TYPES

	Colletotrichum		*Chaetomium* spp.		*Fusarium* spp.		*V. ciliata.*		"K"	
	U*	S*	U	S	U	S	U	S	U	S
Brown lesions ...	28	20	15	8	18	38	8	15	20	12
Corky roots ...	18	18	4	27	17	12	14	—	50	42
Basal rot	48	16	12	23	20	41	9	9	8	—

U* — Unsteamed soil.

S* — Steamed soil.

In the isolations made from brown lesions and basal rot tissue the proportion of *Fusarium* isolates shows a marked rise on steamed soil, while *Colletotrichum* and "K" are less abundant, and this is correlated with a less extensive development of these lesions.

The isolations from corky roots show less variation in the numbers of *Colletotrichum*, "K" and *Fusarium* spp. but the proportion of *Chaetomium* spp. was very much increased. It seems that the corky roots are more specifically due to fungal activity than the brown lesions, the great reduction in their occurrence on steamed soil being due to the change in the soil microflora. This is further supported by the high percentage of fungal isolates made from this type of lesion tissue, whereas isolations from brown lesions show a wide variation both from plant to plant and between the steamed and unsteamed soil. The average percentage isolation of fungi from the different lesion types is shown in Table IV.

TABLE IV

Average Percentage Isolation of Fungi from Different Types Lesion Tissue

	Brown lesions	Corky roots	Basal rot
Unsteamed soil	75	85	67
Steamed soil	33	83	45

The variation in the numbers of fungi isolated from the same type of lesion from roots in steamed and unsteamed soil suggests that the fungi in this type of root rot are either secondary, the change in the soil microflora after steaming leading to a less rapid colonisation of the roots by saprophytic organisms, or that there are several potential pathogens whose efficacy varies with the microbiological and physical soil conditions. The extent to which the lesions develop, however, seems to be largely influenced by the numbers of saprophytic and parasitic fungi in the soil. It was noticed that the numbers of fungi isolated from brown lesions and basal rot tissue tended to vary with the general state of the root system. Thus lesions from plants which had predominantly healthy roots yielded fewer fungi than similar lesions from plants where browning was more widespread on the root system. The improvement in the roots after soil steaming is held to be due not merely to the destruction of pathogenic and saprophytic micro-organisms, but also to the changed physical conditions in the soil, and is probably partly a result of healthier root systems being less susceptible to attack by soil pathogens or to injury by adverse conditions either physical or organic, which may tend to increase later in the year, as the effects of steaming wear off. It seems possible that individual plants of one variety will also vary in their ability to produce relatively resistant roots, and so root systems will vary in the extent of root rot under similar soil conditions.

The differences in the species of fungi associated with tomato roots led to some preliminary investigations to see if these fungi could be isolated from the soil and from the rhizospheres of plants. Both the inner and outer rhizospheres were sampled; the inner rhizosphere, representing the actual root surface, was sampled by shaking roots, freed from all loose soil particles, in sterile water and plating the resulting suspension. The outer rhizosphere was examined by plating a suspension made from the soil shaken from the roots. Several of the species isolated from the rhizosphere in this way have been recorded from the root tissue. *Colletotrichum atramentarium*, *Chaetomium* spp., *Fusarium* spp., *Myrothecium roridum* and *Phytophthora* sp. occurred on plates from both inner and outer rhizosphere although they tended to occur more regularly on plates from the inner rhizosphere. This difference, however, may have been due to the frequent spreading colonies of *Trichoderma viride* on the plates from the outer rhizosphere. The fungi associated with root rot were less abundant than the more general soil fungi such as *Mucor* spp. and *Penicillium* spp. in both inner and outer rhizosphere. *Chaetomium* spp. were recorded from the rhizosphere and from soil plates only during the earlier part of the season, while *C. atramentarium* was not recorded from the rhizosphere until July, concurrent with the rise in numbers isolated from the roots. It appeared to be more frequent in the rhizosphere than in soil further from root influence. *Myrothecium roridum* was recorded occasionally from rhizosphere and soil plates, although it was rarely isolated from root tissue and various species of *Fusarium* were also isolated generally from the inner rhizosphere.

The most striking difference between the inner and outer rhizosphere was in the far greater numbers of *Trichoderma* colonies isolated from the latter which was to a lesser extent paralleled by the behaviour of *Penicillium* spp. On inner rhizosphere plates *Trichoderma viride* appeared regularly up till June but after this was recorded only occasionally, although there was no diminution in its isolation

from the outer rhizosphere. In view of the known antagonism of *Trichoderma viride* to various soil fungi, its non-appearance in the inner rhizosphere during the later part of the season, when root rotting tends to increase, is of interest, and further investigations on its distribution in the tomato rhizosphere are to be carried out.

Inoculation experiments were carried out on plants growing in steamed soil in 10 inch pots. Roots were inoculated when the plants were about six weeks old by dipping the whole root system into a liquid culture of one of the fungal inoculants and repotting. The plants were examined for signs of root rotting 3½ months later. Except for plants inoculated with *C. atramentarium* on which typical symptoms were produced, little difference could be seen between the controls and inoculated plants. Small brown lesions developed on all the plants, but were never extensive, although on inoculated plants the lesions were more common on the central part of the root system which had been inoculated than on the younger roots. Isolations from these plants gave inconsistent results, the inoculant being rarely reisolated. The majority of the fungi recorded from these roots were species of *Fusarium*. From the roots of plants inoculated with *C. atramentarium* the inoculant was regularly reisolated. It was noticed that when *Colletotrichum* was used as an inoculant combined with either *Chaetomium cochliodes* or "K" the damage to the root system was greater than that obtained by inoculating with *Colletotrichum* alone, and that, although *Colletotrichum* was again reisolated from the roots, the other fungi were not. Combinations of other fungi did not produce any more extensive rotting of the roots than that found on the plants inoculated with single cultures.

3. FUNGICIDES

By W. H. READ and R. J. SMITH

Laboratory Investigations

The investigation of the *in vitro* fungitoxic properties of simple quinonoid and related compounds has been continued. In addition, their phytotoxic effects have been determined in tests on young tomato plants (var. "Potentate").

Most of the compounds tested, including some not described in the literature, have been prepared in the laboratory.

Although none of the compounds examined has been found as toxic as 2 : 3-dichloro-1 : 4-naphthoquinone ("Phygon") to the test organism (*Fusarium culmorum*), several items of interest arose from the work.

Nitration of "Phygon" gave a mono-nitro derivative which was half as toxic as the parent compound. 1 : 5-Dichloro-2 : 6-naphthoquinone and quinoline-5 : 8-quinone possess relatively low toxicities. Azobenzene-4 : 4′-quinone was approximately three times as potent as 1 : 4-benzoquinone and one third as potent as 2 : 3 : 5 : 6-tetrachloro-1 : 4-benzoquinone (chloranil or "Spergon"). It is, however, less phytotoxic than chloranil.

2 : 3 : 4 : 4 : 5 : 6-Hexachloro-1 : 4-benzoquinone ("hexachlorophenol") was found as fungitoxic as chloranil but appears too phytotoxic to be of practical value as a fungicide for application to foliage. Young tomato plants sprayed with 0·02 per cent. "hexachlorophenol" showed yellowing of the foliage, similar to that caused by BHC, without the characteristic "hardening" (i.e., reduction in leaf expansion) caused by other quinones at phytotoxic concentrations. The presence of chloroimide groups in the 4-positions of 1 : 4 benzoquinone and 2 : 6 dichloro-1 : 4-benzoquinone resulted in a two-threefold increase in the toxicity to the fungus with no accompanying increase in phytotoxicity.

The fungitoxicity tests were made by a "test-tube dilution" method and the effects on tomato plants determined in comparative tests in which tomato plants, about 9 ins. high and as uniform as possible, were sprayed whilst being rotated on a turn-table, with a standard amount of the fungicide suspended in a dilute aqueous methyl ethyl cellulose.

4. VIRUS DISEASES

By R. HOWLES

(1) Viricides

The investigation of viricidal spray fluids has been continued by studying further the effects of tannic acid and by searching for more effective viricidal substances.

I. Tannic Acid

(a) Effect on the fruit

Ten tomato plants were sprayed with 1 per cent tannic acid solution once a week beginning 14/3/50 when they were 12 inches high and continuing until the experiment was completed. They were not damped overhead, and no harm occurred to the plants.

The fruit was tasted 18 times by 13 different people, none of whom could detect any unusual flavour.

(b) Protective measures for the operator

The Factory Department of the Ministry of Labour and National Service suggests that operators spraying with tannic acid solutions should wear closely fitting eye shields and that the face, neck and hands should also be protected against the tanning effect of the spray.

(c) The effect of spraying young tomato plants with tannic acid solution as a means of retarding the rate of spread of aucuba mosiac disease.

In this experiment 108 seedlings were used. Eighteen of these were inoculated with a standard virus preparation on April 14th, the plants being then at the sixth leaf stage.

The uninoculated plants were placed in two groups, each containing 45 plants forming three identical equidistant lines. On 29/4/50 infected plants were placed in contact with the groups. Six inoculated plants just showing symptoms of infection were separated. One group and three of these plants were sprayed with 1 per cent. tannic acid and then one of the plants was placed at the end of each line of plants in the group so that the three infected plants were adjacent. The other three inoculated plants were placed similarly at one end of the other group. Spraying was repeated once a week. Trimming and repotting occurred when necessary. From 29/4/50 during a period of 15 weeks the plants were examined for symptoms of infection weekly. Plants showing symptoms of infection were kept as close as possible to the infected plants at the ends of the groups. At the same time potted plants corresponding to the ones moved were removed from the other group and put back.

Dates of appearance of mottling are given in Table I.

TABLE I

RATE OF SPREAD OF TOMATO AUCUBA MOSAIC ALONG A LINE OF TOMATO PLANTS SPRAYED WITH 1 PER CENT. TANNIC ACID AND ALONG A LINE OF CONTROLS

Dates of appearance of the disease.
Plants examined until 12/8/50 inclusive.

Sprayed plants					Controls								
17/6	1/7	15/7	15/7		17/6	17/6	15/7	15/7	15/7	15/7	15/7	22/7	12/8
17/6	1/7	8/7	15/7	22/7	27/5	1/7	1/7	15/7	15/7	15/7	22/7	22/7	12/8
24/6	1/7	1/7	22/7		17/6	24/6	1/7	15/7	15/7	15/7	22/7	22/7	12/8

This result is disappointing because although the tannic acid has retarded the spread of the virus to some extent, the effect is so small as to have no practical value.

As this poor result may be due to incomplete covering of the foliage with the solution the effect of adding a wetting agent should be tried.

(d) The effect of a wetting agent on the viricidal action of the spray.

The ability of a solution of tannic acid, 1 per cent., and of the wetting agent, sulphonated lorol, 0·05 per cent, when sprayed on tomato plants to reduce the spread of aucuba mosaic by contact was determined by the method described in the 1948 report (4). A few leaflets of each plant of a group of tomato plants were sprayed, spray being prevented from falling on the soil by a jaconet disc round the base of the stem. The sprayed leaflets were not harmed. A day later they and corresponding leaflets of each plant of a second group of tomato plants were treated with tomato aucuba mosaic virus solution. The results of three experiments are given in Table II. Sulphonated lorol did not inhibit the action of tannic acid.

II. Continuation of the search for spray viricides

The search for spray viricides was continued. Potato virus X was used in autumn when tomato aucuba mosaic symptoms are often indistinct. Results for gallic acid and one for hydroquinone are given in Table II. Spraying with gallic acid caused no harm, but 1 per cent. hydroquinone caused damage. In the case of aucuba mosaic a single result for 1 per cent. gallic acid indicated that the solution was not as good as 1 per cent. tannic acid. When potato virus X was used, 0·5 per cent. gallic acid did not act as a spray viricide, but 0·1 per cent. hydroquinone may act as a spray viricide.

TABLE II

The Effect on the Incubation Period of Tomato Virus Diseases of Spraying Plants with Various Solutions Before Inoculation

Spray	Virus	Number of plants showing symptoms of infection in the head.	
		Sprayed plants	Controls
Solution of tannic acid, 1% and of sulphonated lorol. 0.05%	Tomato aucuba mosaic virus	1 out of 10	6 out of 10
Same solution	Same virus	0 „ „ „	6½* „ „ „
„ „	„ „	3 „ „ „	8 „ „ „
1% gallic acid	„ „	3 „ „ „	6½* „ „ „
0.5% „ „	Potato virus X	6 „ „ „	4 „ „ 9
„ „ „	„ „ „	6½* „ „ „	6 „ „ 10
0.1% hydroquinone	„ „ „	3½* „ „ „	6 „ „ „

* One plant showing slight evidence of infection was counted as half.

(2) Heat Treatment Investigations

I. Tomato Seeds

An attempt was made to inactivate the virus in virus infected tomato seeds by means of heat treatment.

It had been shown here that *Solanum capsicastrum* plants subjected to 105° F. for 60 hrs. after being inoculated weakly with tobacco mosaic virus developed less evidence of infection than controls (2).

Series 1

30 gm. of Ailsa Craig 1948 seed was completely separated and then mixed for half an hour.

Treating *Nicotiana glutinosa* plants with a suspension of the ground seed in water after spraying them with carborundum showed that virus was present. Its nature was determined by treating tomato plants at the 3 foliage leaf stage. This was done on 27/7/50. One month later only symptoms of mild and severe tomato mosaic had appeared.

Heat treatments

Three 4·5 gm. lots of the seed—about 1,500 seeds each—were weighed out. These quantities were heat treated in an atmosphere saturated with aqueous vapour.

Effect of heat treatment on virus content

The virus content of treated seed was compared with that of untreated seed by the half leaf method as described in last year's report (3). The temperature of heat treatment, its duration and the effect of treatment on lesion count are given in Table III.

The results of this experiment show that the virus content of tomato seeds can be reduced very considerably by submitting them to high temperatures for certain lengths of time. At present no practical conclusions have been reached, but the work will be continued.

The effect of the heat treatment on the germination of the seed and consequent growth of the seedling is shown in Table V.

Lengthening the period of heat treatment from 11 to 20 days had a detrimental effect upon the seedlings. Treatment for 11 days at 125° F. caused little harm to the seed itself but left it with a virus content 16 per cent. of that of the untreated seeds.

TABLE III

Effect of Various Hot Air Treatments on the Virus Content of Tomato Seed Infected with Tobacco Mosaic Virus

Treatment			Experiment	Average of two lesion counts carried out on separate days		Mean % decrease in lesion count	% virus inactivated
Relative Humidity	Temperature deg. F.	Duration Hrs.		Treated seed	Control seed		
100	105	60	1	54	113	27	56
			2	101	116		
			3	59	64		
100	115	60	1	18	40	33	63
			2	24	27		
			3	24	32		
100	105	480	1	65	115	47	75
			2	70	160		
			3	80	127		
100	115	360	1	8	16	55	80
			2	10	16		
			3	31	77		
			4	7	17		
100	125	264	1	1½	8	64	84
			2	5	13		
			3	15½	25½		
			4	6½	32		
Normal	135	192	1	1	7	93.5	97.5
			2	2	18		
			3	0	24½		
			4	2	26		

Series 2

Heat treatment was carried out in normal atmosphere at 135° F. for 8 days. The effect on the virus content and on the seed itself are shown respectively in Tables III and IV. The virus present was tobacco mosaic virus.

There was an insignificant amount of virus left and little effect on the seed itself.

As heat treatment makes a plant more susceptible to virus disease it is advisable to sow treated and control seed in order to compare the infected fractions of the resulting plants, continuing growth till the end of the season.

Future investigations should include heat treatment in a normal atmosphere and aim at determining the relation of both the pecentage of virus inactivated and the effect on the seed itself with duration of treatment, temperature of treatment, variety of tomato, age of seed and ripeness of fruit when picked.

TABLE IV

The Effect of Some Hot Air Treatments on Tomato Seed

Treatment			Number of seeds which had germinated out of 50, 17 days after sowing	Appearance of seedlings	Average weight of seedling	Number of normal size seedlings
Relative humidity	Temperature deg. F.	Duration Hrs.				
100	105	480	18	Normal	0·136 gm.	9
100	115	360	23	,,	0·172 ,,	14
100	125	264	42	,,	0·330 ,,	37
100	125	480	24	,,	0·203 ,,	16
Normal	135	192	44	,,	0·323 ,,	38
Control seed	...	...	44		0.354 ,,	

(Appearance of seed which had been heat treated was normal.)

II. Arum Lily Corms

One hundred Arum Lily plants of the smaller species having symptoms of spotted wilt were kindly presented to us by Mr. Breeze. No cucumber mosaic virus was detected by grinding fragments of leaves of the plants in water and applying the suspension to cucumber plants.

Watering ceased at the end of July 1949. The soil was removed from the corms at the beginning of October. The corms were separated into mother and daughter corms.

Lag period in hot water treatment of large corms

The bulb of a clinical (thin) thermometer was inserted completely into a large corm. The junction of the outer surface of the corm and the thermometer was sealed with vaseline. The corm was kept immersed on a wire ring in the apparatus for hot water treatment. The thermometer was read at the end of each 10 minutes from immersion until the temperature became constant. The following data were obtained.

No. of minutes from immersion of corm	10	20	30	40
Temperature ° F.	104	108·2	109·7	109·7

The temperature was that of the bath (109·5° F.) 30 min. from immersion, and almost that 15 mins. later.

Heat treatments

The material was heterogeneous as regards virus content and so one could not as the next step heat treat a number of corms and use the same number of untreated ones as controls. The large corms were just heat treated. The daughter corms, were well mixed, to give homogeneous material, before heat treatment.

Three groups of large corms, 26 in. each, were heat treated in water at 109·5° F., the duration in hours being respectively 2½, 5 and 10. There was a control group of 39 large corms.

The daughter corms were mixed for 15 mins. The corms were divided into 24 groups, 40 per group. Eight groups were given hot water treatment in a tray of water in an electric oven. The temperature of the air in the oven varied from 97·5—117·5° F. between treatments. The water temperature (steady) was about 8° F. below. The duration varied from 2—16 hours. Eight groups received heat treatment in air saturated with aqueous vapour. There were the same temperatures but the duration was 4—300 hours. There were eight control groups.

The corms, large and small, were potted at the beginning of the year.

Effect of heat treatment on the fraction of corms which grew

In the case of the mother corms about half of each heat treated group and of the controls grew. Heat treatment had no effect on the plant itself.

There was very poor growth of the daughter corms. The data is best given by a graph illustrating the relation between the fraction of corms which grew and duration of heat treatment without any reference to temperature. This is done in Fig. 1. The appearance of the plants which grew from the corms was normal. Short periods of heat treatment were found to increase the fraction of corms which germinated. A heat treatment lasting 30 hours produced maximum effect.

The effect of heat treatment on the number of infected plants which arose from the corms

The three heat treatments of the large corms resulted in no control. On 19/6/50 the number of plants showing symptoms of spotted wilt was 8, 6, 7 and 18 for the heat treatments in the above order and controls respectively.

In the case of the daughter corms the results are expressed graphically in Fig. 2. There was least occurrence of symptoms of infection at 16 hours; compared with the controls the reduction was about 50 per cent. Long heat treatment made the plants more susceptible than the controls to infection. The best temperature was 117·5° F. Considering the small number of corms involved the experiment must be repeated. In the repeat "grand daughter corms" (size of a pea), which formed a considerable part, should be excluded.

(3) Chemotherapeutic Work

An experiment consisted of four groups of potted tomato plants, 10 per group. Beginning a day before inoculation the soil in each pot received 100 ml. of water each day. A jaconet disc was

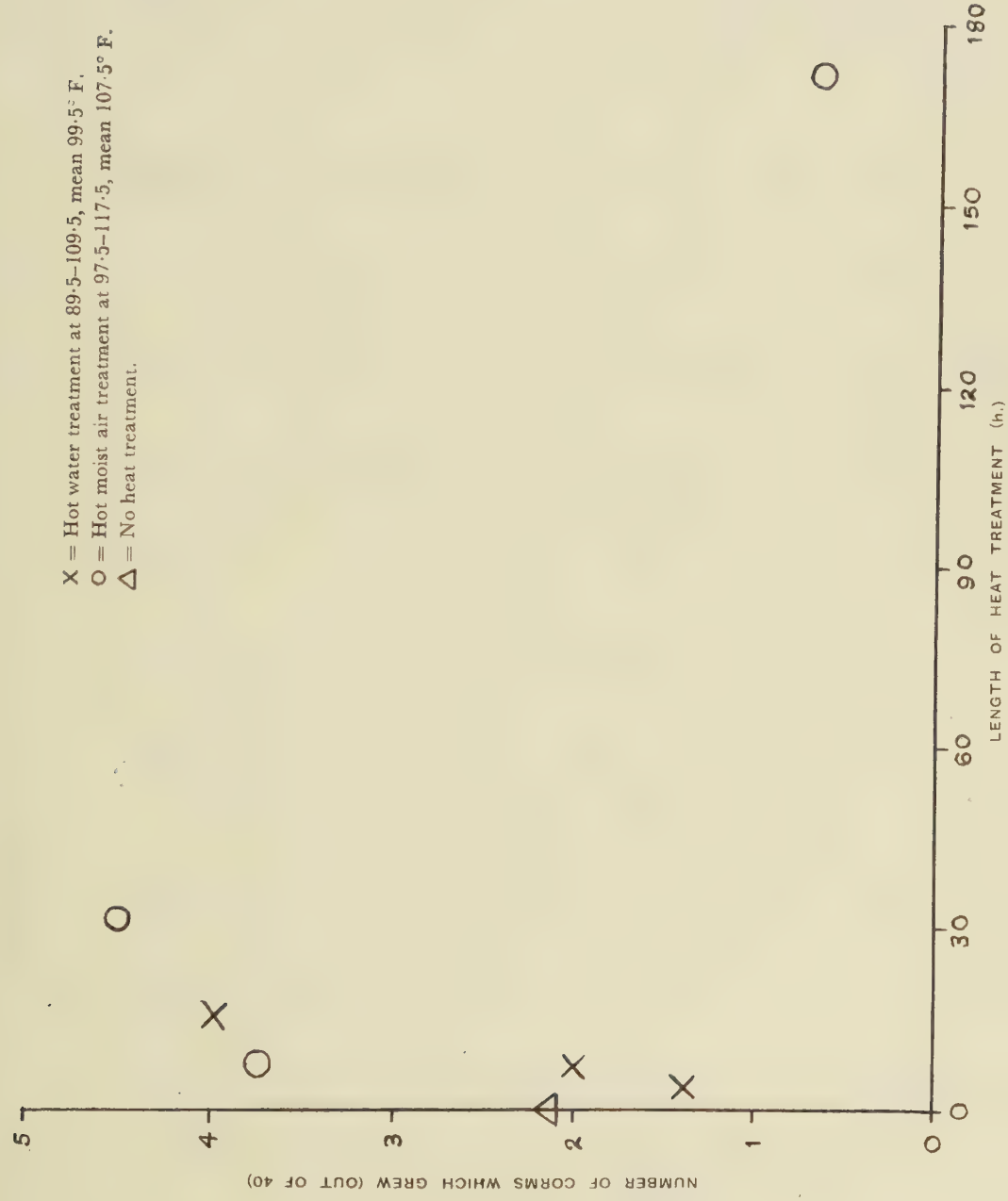

Fig. 1

Relation between number of heat treated Arum Lily corms which grew and duration of heat treatment.

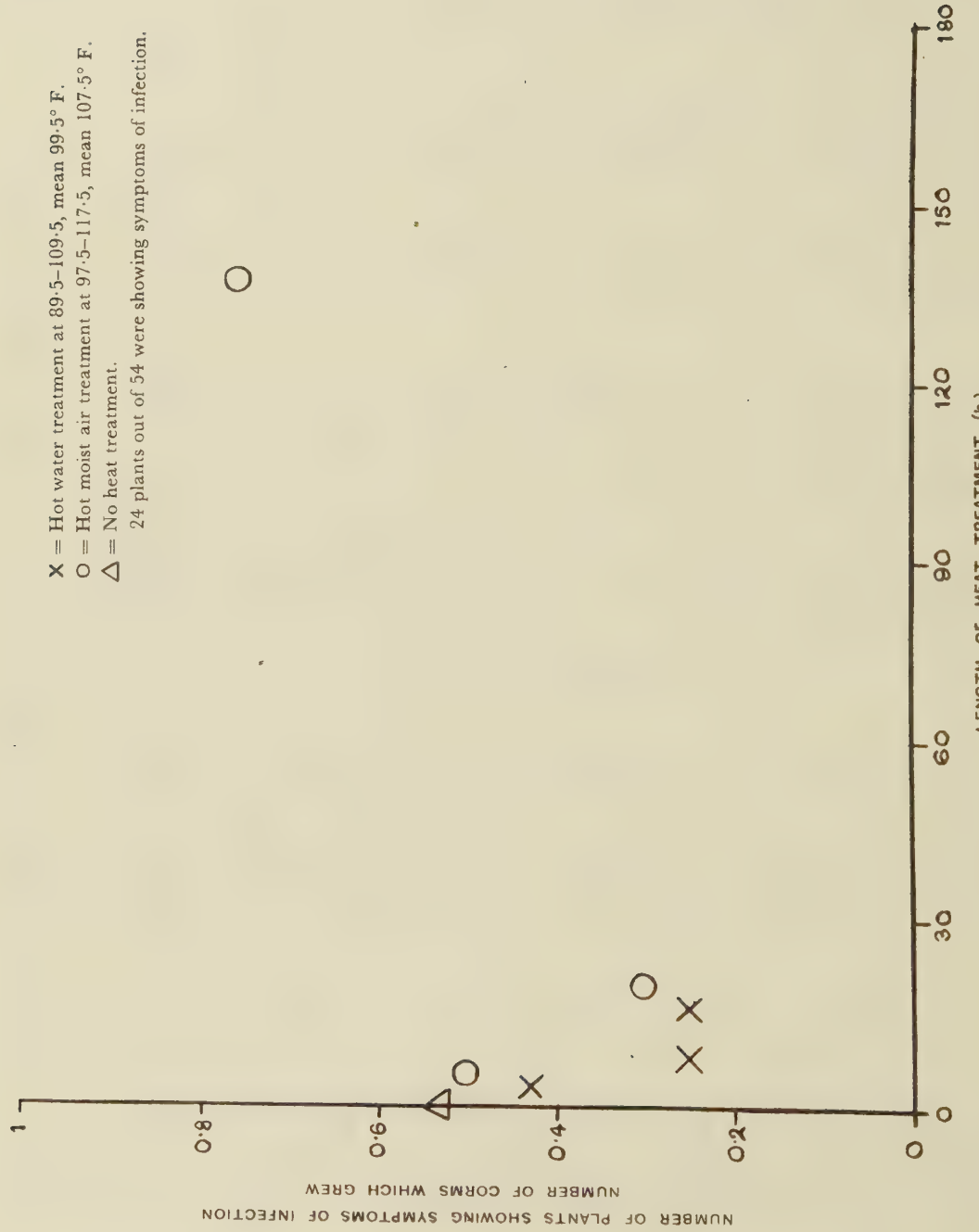

Fig. 2

Effect of heat treatment on the development of spotted wilt in Arum Lily plants.

fastened round the stem of each plant; the disc was immediately above the cotyledons. The plants, at the six foliage leaf stage, were inoculated with tomato aucuba mosaic virus in spring and summer and potato virus X in autumn as described in the 1948 Annual Report under spraying experiments (2). Commencing the next day after the date of inoculation one group acted as controls and in the case of each of the others either the soil in each pot instead of 100 ml. of water each day received 100 ml. of a chemical solution each day for 10 days or each plant was sprayed with 25 ml. of a chemical solution once each day or two days for eight days. The discs prevented spray from falling on the soil. Unless otherwise stated none of the treatments mentioned in the adjoining table (V) harmed the plants. The number of plants showing symptoms of infection in the head in the case of each group was recorded with the number of plants in the group when about half the controls were so diseased.

Results

Table V contains the effect of chemical solutions applied to soil and as sprays to the foliage on the development of symptoms of infection.

TABLE V

THE EFFECT OF CHEMICAL SOLUTIONS APPLIED TO THE SOIL AND AS SPRAYS TO THE FOLIAGE ON THE DEVELOPMENT OF SYMPTOMS OF VIRUS INFECTION

Chemical solution	Mode of Application to the plants	Virus	Experiment	Number of plants showing symptoms of infection in the head	
				Treated plants	Controls
0.1% potassium permanganate	Applied to the soil	Tomato aucuba mosaic virus	1	3½* out of 10	6 out of 10
			2	4½† ,, ,, ,,	6½* ,, ,, ,,
			3	5 ,, ,, ,,	5½* ,, ,, ,,
	Sprayed on the foliage	Same virus	1	1½ ,, ,, ,,	6 ,, ,, ,,
			2	4½* ,, ,, ,,	6½* ,, ,, ,,
			3	4 ,, ,, ,,	5½* ,, ,, ,,
0.025% malachite green ...	Applied to the soil	Same virus	1	0 ,, ,, ,,	6 ,, ,, ,,
			2	3½* ,, ,, ,,	6½* ,, ,, ,,
			3	½ ,, ,, ,,	5½* ,, ,, ,,
	Applied to the soil	Potato virus X	1	0 ,, ,, ,,	6 ,, ,, ,,
			2	3 ,, ,, ,,	9 ,, ,, ,,
			3	0 ,, ,, ,,	5 ,, ,, ,,
	Sprayed on the foliage	Tomato aucuba mosaic virus		1 ,, ,, ,,	5 ,, ,, ,,
0.00625% malachite green ...	Sprayed on the foliage	Potato virus X		0 ,, ,, ,,	5 ,, ,, ,,
Solution of urea, 0.025%, and of potassium bi-carbonate, 0.025%	Applied to the soil	Tomato aucuba mosaic virus		6½* ,, ,, ,,	5 ,, ,, ,,
	Applied to the soil	Potato virus X	1	4 ,, ,, ,,	4 ,, ,, 9
			2	9 ,, ,, ,,	6 ,, ,, 10
	Sprayed on the foliage	Tomato aucuba mosaic virus		4 ,, ,, ,,	7 ,, ,, ,,
	Sprayed on the foliage	Potato virus X	1	4 ,, ,, ,,	4 ,, ,, 9
			2	2 ,, ,, ,,	5 ,, ,, 10

* 1 plant showing slight mottling was counted as ½.

† 3 plants showing slight mottling.

0·025 per cent. and 0·00625 per cent. malachite green caused respectively in summer slight and in autumn moderate harm to the plant.

Summer experiments (tomato aucuba mosaic virus). 0·1 per cent. potassium permanganate applied to the soil, the same solution applied to the foliage, 0·025 per cent. malachite green applied to the soil and solution of urea, 0·025 per cent., and of potassium bicarbonate, 0·025 per cent., sprayed on the plant each slightly diminished the size of the plant. Neither 0·025 per cent malachite green sprayed on the plant nor this urea—potassium bicarbonate solution applied to the soil affected the size of the plant. 0·025 per cent. malachite green applied to the soil slightly darkened the colour of the foliage.

Autumn experiments (potato virus X). Neither the urea-potassium bicarbonate solution applied to the soil nor sprayed on the plant affected its size and the same applied to 0·025 per cent. malachite green watered on the soil and to 0·00625 per cent. malachite green sprayed on the plant. Watering the soil with the urea-potassium bicarbonate solution and 0·025 malachite green per cent. each darkened the colour of the foliage as did spraying with 0·00625 per cent. malachite green.

Discussion

Malachite green had a pronounced retarding effect on the development of symptoms of tomato aucuba mosaic. It has been suggested that Stoddard and Dimond's results were due to masking. The symptoms of aucuba mosaic were not affected by the malachite green, but there may have been masking (blue + yellow = green) due to any irregular distribution of the substance. It was because of this possibility that the work was repeated using potato virus X which produces brown lesions on the foliage. The same retarding effect was obtained. The symptoms on the treated plants and the controls were the same.

In the case of potassium permanganate there was a slight retarding effect.

Treating the soil with solution of urea, 0·025 per cent., and of potassium bicarbonate, 0·025 per cent., did not affect the development of symptoms due to potato virus X. The same solution as a spray may be a therapeutic agent.

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1 2

PLATE I. SPECIES OF RHIPIDOTHRIPS x 30

Fig. 1. *gratiosus Uz.* Female

Fig. 2. *brunneus Will.* Female (*brachypterous*)

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PLATE II. SPECIES OF MELANTHRIPS x 30

Fig. 3. *fuscus Sulz.* Male

Fig. 4. *fuscus Sulz.* Female

Fig. 5. *ficalbii Buffa.* Female

III. ENTOMOLOGICAL INVESTIGATIONS

1. GLADIOLUS THRIPS (Taeniothrips simplex Mor.)

By E. R. SPEYER and W. J. PARR

On July 27th, 1950, Gladiolus plants upon a small market-garden at Edmonton, Middlesex, were found to be severely infested by the Gladiolus Thrips. This is the first authentic record of the insect in Europe, though there can be little if any doubt that the species has been imported into England upon corms obtained from the continent.

Specimens were compared with the type, collected from a carnation flower in South Australia in 1928 and now in the British Museum collection, and there can be no question of their being identical with *T. simplex* Mor.

During August, collections of Thysanoptera from Gladiolus in Berkshire, Gloucestershire and Lincolnshire, were submitted for determination by the Ministry of Agriculture's Laboratory at Harpenden: all contained specimens of *T. simplex.*

Extensive "silvering" of the foliage and flower-petals, caused by feeding of the insects, affords reliable evidence of the presence of the true Gladiolus Thrips: in cases of severe infestation, flower-buds may also fail to form or expand their petals, and open flowers may die off prematurely.

Collections of Thysanoptera from Gladiolus flowers which exhibited little or no injury in Hertfordshire and North of England gardens during July and August revealed the presence of 10 indigenous British species, two of which, in their larval stages, are predatory on other insects, and the remainder of which comprised adult insects which had merely assembled on the flowers in order to feed upon pollen grains or nectar: four species amongst the latter are known to be injurious to plants other than Gladiolus, but had neither bred in the flowers nor fed to any appreciable extent upon the petals.

A brief account of the pest, illustrated with figures on Plates III and IV, and containing reference to control measures will be found under "Growers' Notes" on pp. 62. A fuller account dealing also with morphological characteristics by which *T. simplex* may be separated from some common British species of the genus is being published by the Royal Entomological Society of London at the meeting of which, on September 6th, the occurrence of the insect in England was first announced.

2. TOMATO LEAF-MINER (Liriomyza solani, Her.)

By E. R. SPEYER and W. J. PARR

There has been a very notable decrease in this Leaf miner upon nurseries in the Hertfordshire Lea Valley during the growing season of 1950. Infestation of seedlings in propagating houses appears to have been conspicuous by its total absence. Material for further investigation, especially into the cause of a considerable proportion of the adult insects being unable to effect their escape from the puparia, could therefore, not be obtained.

It is suggested that an increase in the population of Hymenopterous parasites has been responsible for decrease of the Leaf-miner.

3. STUDIES UPON THYSANOPTERA

By E. R. SPEYER and W. J. PARR

I. Genus Rhipidothrips

Only two species of the genus appear to be represented in the British Isles; *R. gratiosus* Uzel (Plate I, Fig. 1) occurs chiefly on Oats in the southern counties, and *R. brunneus* Williams (Plate I, Fig. 2) has been collected from Bromus grass in Sussex by Williams (1913 pp. 216–218) and Bagnall (1930, p. 47).

Of the specimens examined, both sexes of the former were macropterous, and females of the latter species brachypterous, though the macropterous form would appear to occur in Sweden. 2nd instar larvae of *R. gratiosus* show structural affinities with those of species in the genera Aeolothrips and Melanthrips.

The two species are separable upon the following characteristics:—

1. (2) Posterior region of head, in dorsal aspect, with conspicuous reticulate area, bounded anteriorly by an arcuate suture. 2nd antennal segment pale. Seta in each posterior lateral angle of pronotum long (about 75μ) and fine. Ninth and tenth abdominal tergites of female unicolorous—*gratiosus* Uzel.
2. (1) Posterior region of head, in dorsal aspect with a transverse suture and a few simple transverse striations. 2nd. antennal segment dark. Seta in each posterior lateral angle of pronotum of moderate length (about 50μ) and stout. Tenth abdominal tergite of female paler than ninth—*brunneus* Williams.

The male of *R. gratiosus* resembles the female in the characteristics cited: whereas the striations upon portions of the head, pro- and meso-notum, and 1st to 7th abdominal tergites are densely beset with microtrichia, those upon the abdominal tergites of the female are devoid of microtrichia. The male of *R. brunneus* does not appear to be known: in the female, the striae upon the head, thorax, and abdomen are devoid of microtrichia.

In both species a few forwardly-directed setae, which are stouter than others in their vicinity, occur in a longitudinal row along the lateral margins of the head behind the eyes. The number of these setae is variable and it is conceivable that they might be entirely wanting in some specimens. Setae of a similar nature may be present or wanting in at least one species of the genus Aeolothrips. Differences in the number and length of the weakly sclerotised setae upon the posterior margin of the pronotum do not, on account of overlapping, afford diagnostic characteristics of any value for the separation of the two species from one another: in *gratiosus* there are 6 to 8 setae, 18—45μ long, and in *brunneus* 4 to 6 setae 10—25μ long.

Examination of the type female of *R. uzelianus* Bagnall (from Switzerland) in the British Museum collection failed to reveal any structural characteristics by which the specimen is separable from *R. gratiosus* Uzel. Bagnall (1934 p.482) gives the length of the hind tibia as 295μ and the dimensions of the 4th antennal segment as 80 (27)μ for the female of *gratiosus*, and respective measurements of 242μ and 59 (25)μ for that of *uzelianus*. For six females collected by C. B. Williams and R. S. Bagnall from oats at Oxford and in Berkshire during July 1913, the dimensions in μ are:—

Hind Tibia	*4th antennal Segment*	
Length	*Length*	*Diameter*
305	71	26
299	77	26
282	70	23
266	61	23
263	79	24
249	51	23

The measurements indicate clearly that *R. gratiosus* Uz. is variable in size and that *R. uzelianus* Bagnall, is a small specimen of the former species, with which it is therefore synonymous.

Reuter (1899 p.30) described a species of Rhipidothrips from Sweden under the name *niveipennis*. Williams (1916 pp. 221-222) examined one of Reuter's specimens, pointed out that it did not agree with the description, and naturally concluded that the latter was inaccurate. There is, however, in the British Museum collection, a specimen collected in Sweden by Hukkinen which certainly agrees with the description given by Reuter for *niveipennis*. This macropterous female shows no trace of a seta (or its alveolus) in the posterior lateral angle of the pronotum which, incidentally, has only one pair of feebly sclerotised setae, upon its posterior margin.

Priesner (1930, p. 39), dealing with Reuter's types, states that *niveipennis* is easily recognisable, and has been found again by Ahlberg and Hukkinen. It would appear probable, therefore, that Reuter had two distinct species before him, one of which was *niveipennis*, of which he gave an accurate description, and the other the macropterous female of *brunneus* Williams.

From an examination of a series of specimens from Sussex, it has been concluded that the characteristics given by Williams in his key (1916, p. 221) are quite inadequate for the separation of *brunneus* from the specimen which he refers to as *niveipennis*.

The basic synonymy of the European species, as at present known, therefore becomes:—

gratiosus (Uzel 1895) Priesner 1928. uzelianus Bagnall, 1934.
niveipennis Reuter, 1899: nec Williams, 1916.
brunneus Williams, 1913.

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PLATE III. GLADIOLUS THRIPS (*Taeniothrips simplex Mor.*) x 30
Fig. 6. Male
Fig. 7. Female

PLATE IV. Injury caused by Gladiolus Thrips to leaves, flowers-buds and open flowers of Gladiolus (Photograph on left by E. S. Skillman.)

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II. Genus Melanthrips *

In recent lists, the British forms of Melanthrips appear under four or five different specific names, but for reasons given hereafter, it is considered that only two are true species.

M. fuscus Sulzer (Plate II, Figs. 3 and 4.), the type of the genus, abounds in flowers of Charlock during late spring and in summer, but appears to be less common in the north than in the south of England.

M. ficalbii Buffa (Plate II, Fig. 5), is probably restricted to the southern counties, where it has been recorded amongst others from flowers of Reseda, Rock-rose, Goose-grass, Potentilla, Stitchwort and Strawberry.

Larvae (1st and 2nd instar) of *M. fuscus* collected in Hertfordshire during June show close structural affinities with those of Aeolothrips and especially Rhipidothrips; unlike those of Aeolothrips they are believed not to be of predaceous habit. The European representatives of the genus would appear to exist exclusively as macropterous forms, and the two British species are readily separated from one another upon differences in the colouration of the fore-wing. It is, however, by no means certain that brachypterous or even apterous forms might not occur, and on this account such other characteristics as are considered to be constant for their separation are added.

1. (2) In both sexes, forewing, except at base, more or less uniformly shaded grey or brown: pronotum beset with transverse rows of microtrichia. In females, 3rd to 6th abd. sternites beset with accessory setae.....*fuscus* Sulzer.
2. (1) In both sexes, forewing hyaline with dark bar across middle, and shaded area at apex: pronotum devoid or almost devoid of microtrichia. In females, only 3rd and sometimes 4th abd. sternite beset with accessory setae. *ficalbii* Buffa

The particular abdominal sternites upon which accessory setae occur, afford, as far as can be ascertained, a reliable characteristic for the separation of females, but not of males, of the two species. The actual number of these setae on each sternite is subject to considerable variation. In three males and nine females of *M. fuscus*, collected from Charlock in various localities, and in four females of *M. ficalbii* obtained from strawberry in Kent by Dr. C. L. Odam, the accessory setae were distributed as follows:—

No. of accessory setae on abdominal sternites.

	II	III	IV	V	IV	VII
fuscus ♂	0–2	2–3	0–2	0–1	0–2	0–1
„ ♀	0–2	4–7	4–6	2–6	2–4	0
ficalbii ♀	0	4	1–3	0	0	0

The overall length of the females referred to was 1·95 ± 0·30 mm. for *fuscus*, and 1·65 + 0·60 mm. for *ficalbii* : the average length, with range of variation (±) in μ of each of the 9 antennal segments was:—

fuscus: 34 ± 8: 50 ± 5: 66 ± 3: 71 ± 6: 50 ± 5: 59 ± 7: 40 ± 2: 26 ± 2: 34 ± 2: Total 430 ± 40.

ficalbii: 35: 44 ± 1: 57 ± 2: 56 ± 4: 44 ± 1: 53 ± 2: 40 ± 2: 25 ± 3: 29 ± 1 Total 383 ± 13.

The 3rd antennal segment of *fuscus* would therefore appear, on the average, to be shorter than the 4th, and both segments to be of equal length in *ficalbii*. The range of variation, however, even in

* In 1838 Burmeister used the name Melanothrips, over which Haliday's Melanthrips must be regarded as holding priority.

these small series, is such that no reliance can be placed upon the relative length of the segments as a characteristic for separating the two species; the same also applies to males of the two species.

Melis (1933) attempted to separate species in this genus principally upon differences in curvature of the abdomen (of females) and in the chaetotaxy of the antennal segments, characteristics which respectively were stated by himself (1934 p.1) and by Priesner (1936, p. 31) to be of no value for that purpose. At least in *M. fuscus*, the disposition of setae upon the antennal segments was often found to differ upon the antenna of each side in a single specimen.

Priesner (1936) sought to separate the European and North African species largely upon differences in the conformation of the sensoria upon the 3rd and 4th antennal segments, the relative lengths of some of the antennal segments to one another, and in the chaetotaxy of the pronotum. In his figures (loc. cit. Plate II, 1–19) he has delineated only the course of the "lumen" of the sensoria, and specimens in all other respects resembling *M. fuscus* are to hand in which the sensoria do not differ appreciably from those of *M. fcalbii*. Variation in the length of the antennal segments has been dealt with above, and there is no significant difference in the chaetotaxy of the pronotum (loc. cit. pp. 32 and 46) between the two species, which, incidentally, Priesner places in different sub-genera.

Other British forms to which specific names have been given by Priesner and Bagnall are:—

M. gracilicornis Maltbaek: described as a variety of *fuscus* Sulz., redescribed as a species by Priesner (1936, pp. 33–34), who includes *bisetosus* Bagnall as a synonym. Priesner (1936, p. 50) separates *gracilicornis* from *fuscus* by the greater length of the 6th antennal segment (63–72μ as against 50–60μ) and of the eye (80–88μ as against 64–78μ). He also states that there are *usually* two "ante-apical" setae (see Morison 1949, p. 72, Fig. 13) upon the outer margin of the hind tibia, as compared with only one in *fuscus*.

Amongst 14 females collected from Charlock at Harpenden, Herts, on June 19th, 1940, by C. B. Williams, in which the length of the 6th antennal segment is $53 \pm 7\mu$, and which (according to Priesner) are therefore referable to *fuscus*, 11 have one and 3 have two pre-apical setae on each hind tibia. Amongst females collected in Hertfordshire and Northumberland also from Charlock in which the 6th antennal segment measures $59 \pm 7\mu$, the number of pre-apical setae varies from one to two, and in some cases the number is not the same on the tibia of each side of the same specimen. In males of *fuscus* these setae are sometimes entirely wanting.

It is concluded that the number of pre-apical setae upon the hind tibia is quite inconstant in *fuscus*, and is not correlated with the length of the 6th antennal segment. As Priesner (1936, p. 33) states that "*gracilicornis*" is usually associated with *fuscus* upon the same host-plant, it would appear that specimens which have been given the former name are merely rather larger examples of the latter species, in which, naturally, the antennal segments, the eyes, and the setae upon the pronotum are longer than in smaller specimens of *fuscus*. There are no reasons, therefore, for considering "*gracilicornis*" to be specifically different from *fuscus*.

M. harrisoni Bagnall (1930, pp. 48–9): the species is founded upon a single teneral female swept from low herbage near Sandhurst, Kent, in June 1929. On account of the poor condition of the specimen, now in the British Museum collection, microtrichia which might have been present, if not upon the pronotum, at least on the mesonotum, are not visible. It is, however, possible (though with difficulty) to see accessory setae upon each of the 2nd to 5th abdominal sternites, which would associate the insect rather with *fuscus* Sulz, than with *acetosellae* John as implied by Bagnall and Priesner (1936, p. 42). Contrary to Bagnall's account, there appears to be a pre-apical seta (over 45μ in length) at least upon one hind-tibia. One antenna of the specimen is deformed, the 5th to 9th segments having coalesced to form two monstrous segments. Of the other antenna, the several segments measure in μ: 21: 35: 56(25): 63(23): 50(20): 45(21): 28(20): 21(12): 32(10): Total 351. While the 3rd segment is shorter than the 4th and not sub-equal as stated by Bagnall, the only difference from *fuscus* lies in the much shorter 7th segment which normally is about 40μ long in the latter species. There can be no doubt that the specimen is merely a small female of *M. fuscus* Sulzer with one deformed and one slightly aberrant antenna.

M. angusticeps Bagnall (1924, pp. 2–3): the type male and female collected at Cholsey, Berkshire, and a number of females at Warlingham, Surrey, in June 1925, on Rock-rose (Helianthemum) are in the British Museum collection. A female co-type was re-described by Priesner (1936, p. 47) and included under *M. fcalbii* Buffa, with which it is undoubtedly identical.

M. anglicus Priesner (1936, pp. 47–8): described from a single imperfect specimen collected by Bagnall at Yarnton, Oxfordshire, in June 1913—habitat not stated. There are no characteristics given in the description which would serve to separate the insect from *M. fcalbii* Buffa.

The basic synonymy of British species of Melanthrips becomes:—

fuscus (Sulzer 1776) Priesner 1936.
harrisoni Bagnall 1930.
gracilicornis (Maltbaek 1931) Priesner 1936.

ficalbii (Buffa 1907) Priesner 1936.
angusticeps (Bagnall 1924) Priesner 1936.
anglicus Priesner 1936.

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III. British Genera of Aeolothripidae

Having investigated the characteristics by which species respectively in the genera Aeolothript (see Speyer and Parr, 1948 and 1949), Rhipidothrips, and Melanthrips, may be separated, an attemps is now made to set out characteristics which serve to separate the genera from one another.

In dealing with a restricted fauna within a small geographical area, the necessity of examining European and some North American species in these and allied genera has not been overlooked. First, it is important to point out that more recent authors have raised a family "Melanthripidae" to include the genus Melanthrips: partly for the sake of convenience, but more especially on account of the close relationship in general structure both of the imagines in this genus and 1st and 2nd instar larvae of *Melanthrips fuscus* Sulz., with those of Aeolothripidae, the genus Melanthrips is here restored to the latter family.

The genera Melanthrips and the closely allied European Ankothrips have hitherto been regarded as containing more primitive forms than Aeolothrips and Rhipidothrips. For this view there would appear to be little justification since in the former genera the segments of which the labial palpi are composed are reduced in number, and the cephalic and pronotal chaetotaxy show a markedly higher degree of specialisation.

The venation of the forewing affords little assistance for the purpose of placing the several genera in their probable sequence of phylogeny, for the number of cross-veins is liable to inconstancy within the species. Priesner (1926) gives the number of cross-veins for Ankothrips as 5, and Mr. F. Laing has kindly confirmed this to be the case in females of *A. niezabitowskii* Schille from Hungary in the British Museum collection; for Melanthrips the number appears to be 3 in males and 3 or 4 in females of the same species, for Aeolothrips 4 and rarely 3 or 5, and for Rhipidothrips 3—4, but the presence of these veins is often difficult to determine, even in good preparations.

The following key comprises characteristics which would appear to be common to species in each of the three British genera, and may serve to separate these genera from one another:—

1. (4) Head: dorsal setae very short, of nearly uniform length: greater portion of post-ocular region beset with setae. Labial palpi 4-segmented. Antennae (normally 9-segmented) with some distal segments connate.
Pronotum: surface, except on or near posterior margin, beset with short setae of uniform length.
Fore-tibia: with stout spine-like setae ventrally near apex.
Fore-tarsus: with uncus ventrally at apex of distal segment.
Fore-wing: in macropterous forms, cilia along anterior margin wanting.
Abdomen: 3rd to 7th sternites of male devoid of accessory setae: 7th sternite of female beset with accessory setae.

2. (3) Antenna with ventral sensorium on 3rd and 4th segments longitudinal: 5th to 9th segments (normally) connate. Setae upon posterior margin of pronotum little longer or stouter than those upon remainder of surface. In female, 3rd to 6th abdominal sternites devoid of accessory setae: 9th abd. tergite with short unpaired median seta on posterior margin.... *Aeolothrips* (Haliday, 1836)

3. (2) Antenna with ventral sensorium at apices of 3rd and 4th segments transverse: 7th to 9th segments (normally) connate. Some setae on or near posterior margin of pronotum, much longer than those upon remainder of surface. In female, 3rd to 6th abdominal sternites beset with accessory setae: no unpaired median seta on posterior margin of 9th abdominal tergite .....*Rhipidothrips* (Uzel, 1895)

4. (1) Head: dorsal setae stout and of unequal length: post-ocular region with a single transverse row of long stout setae. Labial palpi 2-segmented. Antennae (normally 9-segmented) with all segments separate.
Pronotum: beset with some long setae in all regions.
Fore-tibia: with prominent tri-cuspid process ventrally at apex.
Fore-tarsus: devoid of uncus.
Fore-wing: under surface near anterior margin sparsely beset with cilia.
Abdomen: at least the 3rd sternite beset with accessory setae in both sexes: 7th sternite of female devoid of accessory setae. *Melanthrips* (Haliday, 1836)

Owing to the frequency of abnormalities, especially of the more distal segments, it has been necessary to include the word "normally" when referring to the segmentation of the antennae: such aberrations may sometimes occur symmetrically in the antenna of each side of a single specimen.

Priesner (1926, p. 84) implies that the larva[e] of Melanthrips possess a 4-segmented maxillary, and a 3-segmented labial palpus.

From an examination of a considerable number of 1st and 2nd instar larvae of *Melanthrips fuscus* Sulz., it is clear that the maxillary are 3-segmented and the labial palpi 2-segmented. In larvae of the several species of Aeolothrips which have been obtainable, and of *Rhipidothrips gratiosus* Uz., the maxillary palpi are distinctly 4-segmented and the labial palpi 3-segmented.

The specialised median and lateral setae, wrongly referred to as "processes" by Speyer and Parr (1941, p. 585), dorsally upon the 9th abdominal somite of the 2nd instar larvae are, in Aeolothrips of sub-equal length; in *R. gratiosus* the setae of the lateral are rather larger than those of the median pair, with the alveoli of all, thicker. In *Melanthrips fuscus*, on the other hand, the setae of the median pair are considerably larger than those of the lateral pair, with the alveoli prolonged to form sockets round their bases—a condition which evidently led Melis (1933, p. 85 Figure XXIV.I.) erroneously to portray the larva as possessing 5 instead of 2 pairs of these specialised setae. Reduction in the number of segments of which both the maxillary and labial palpi are composed and the greater specialisation of setae upon the 9th abdominal somite as exhibited in larvae of Melanthrips would appear to be factors which lend further weight to the conclusion that this genus is considerably more specialised than Aeolothrips. Rhipidothrips is closely allied to, but rather more specialised than Aeolothrips.

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4. INSECTICIDES

By W. H. READ and R. J. SMITH

(A) Laboratory Investigations

Acaricides

The combination of azobenzene as an ovicide with parathion, a highly potent acaricide against active stages of the glasshouse red spider mite (*Tetranychus telarius*), whilst affording excellent control, has certain disadvantages. Azobenzene hardens the growth of young cucumbers to such an extent that its use on plants in pots, or recently planted out in the borders, is not advisable. Parathion has a very high mammalian toxicity and the amount which can be applied to glasshouse food crops is restricted by the necessity to avoid residues hazardous to workers or consumers of treated food products.

Alternative compounds for the control of this pest are being sought, therefore, in view of the above considerations and the possibility that there may arise in this country strains of the mite resistant to parathion, as has occurred in America.

A number of phenyltrichloromethylcarbinols, prepared by Prof. Wain (Wye College) were examined for ovicidal properties. None of these compounds are sufficiently ovicidal to be of practical value although *para*-chlorophenyltrichloromethylcarbinol and its acetate were appreciably toxic. Ovicidal action was increased by substituting chlorine into the *para* position of the phenyl nucleus and reduced by esterification. A more detailed account of this work will be given elsewhere.

Compounds which were regarded as being likely to have acaricidal properties, or which would be of value in investigations of the effect of chemical constitution on acaridical and ovicidal action have been prepared. In addition several compounds and products which other workers have found highly toxic to certain mites, have been examined.

Preliminary results showed that 4-chlorophenyl 4-chlorobenzenesulphonate was somewhat less toxic to red spider eggs than the 4-chlorophenylbenzenesulphonate. Both compounds were potent ovicides. Benzylidene-aniline and benzylidene-4-chloroaniline showed promise as ovicides and appeared to have some residual action against newly hatched larvae. Acetophenone-anil and 4 : 4′-dichlorobenzophenone oxime, although appreciably ovicidal, were less promising whilst the oxime of 4-chlorobenzophenone was much less toxic to red spider eggs.

"Aramite," a product stated to contain 95 per cent. *beta*-chloroethyl-*beta*-(*p*-tert. butylphenoxy)-*alpha*-methyl-ethyl sulphite, and 0.7-hydroxy-4-methylcourmarin-0·0 diethyl thiophosphate (E838), the active constituent of "Potasan," were assayed as ovicides. The former was highly ovicidal whereas the thiophosphate was not sufficiently potent to be of practical value as an ovicide.

(B) Glasshouse Trials

(1) Red Spider. The performance of methanesulphonyl fluoride was examined in glasshouse trials. Whereas complete control of active stages of red spider mite was obtained in laboratory trials by the volatilisation of methanesulphonyl fluoride at the rate of 3·0 grams per cubic feet, a dosage equivalent to 4 grams per 1,000 cubic feet was required in glasshouses when the fumigation was effected by sprinkling the liquid onto the path of the house.

Cucumbers and tomatoes were undamaged by this dosage. Aphids (*Doralis symphiti*) on cucumbers were effectively controlled by a dosage of 3·3 grams per 1,000 cubic feet under the conditions. of these tests.

Information is not yet available concerning the possibility of absorption of methanesulphonyl fluoride by fruits and other hazards which might arise from the use of methanesulphenyl fluoride which is very poisonous to mammals. The absence of ovicidal action, and the low efficiency of methanesulphonyl fluoride in destroying resting stages of red spider are obvious disadvantages.

In the absence of a satisfactory technique for the laboratory testing of compounds against active stages of red spider spraying trials were made on tomato plants for the preliminary assessment of their value for the control of this pest. Such trials do not permit critical comparisons of acaricidal value. Tests with the manufactured product "Dimite" (25 per cent. bis-(*p*-chlorophenyl) methyl carbinol) showed that all stages of red spider were effectively controlled by a single application at 0·1 per cent. Adult female mites placed on tomato plants 2 days after spraying with Dimite at this concentration were able to re-infest the plants. The product injured tomato foliage at this concentration. Applications at 0·05 per cent. gave insufficient control.

Promising results were obtained in spraying tests with a wettable powder containing 15 per cent. of "Aramite" at a dilution of 1 in 400, i.e., 0·04 per cent. active ingredient. Larvae hatching from eggs 9 days after spraying appeared to be killed by residual action. "Dilan," a product containing 2-nitro-1 bis (*p*-chlorophenoxy) propane and the corresponding butane, had poor acaricidal properties.

Chloropicrin as a soil treatment

An experiment was conducted in a tomato house to gain information regarding the relative merits of steam sterilisation and soil treatment with chloropicrin against the tomato root eelworm. Four plots, each 16 sq. yds., were steamed in the usual manner to maintain a temperature of 210° F. and four similar plots were treated by injecting chloropicrin. Injections of 4 ml. were made at 12 inch intervals at a depth of 6 inches, the rate of application being 15 lbs. chloropicrin per 100 sq. yds. Immediately after completing the injection of a plot the soil surface was sealed by a light watering of approximately ½ gallon per sq. yd. to prevent too rapid volatilisation of the chloropicrin.

The mean of the yields obtained from the plots treated with chloropicrin was equivalent to 65·6 tons per acre and the mean of the steamed plots 65·9 tons per acre. The difference between these yields is not statistically significant. The roots in all plots were free from eelworm attack.

IV. CHEMICAL INVESTIGATIONS

1. THE NITROGEN OF SOME BONE MATERIALS USED IN HORTICULTURE *

By G. W. WINSOR and M. I. E. LONG

Bone meals, though usually considered as predominantly phosphatic fertilisers, are sold on a basis of both phosphoric acid and nitrogen. There is little doubt that the presence of this nitrogen has contributed considerably to their established use in horticulture. When, therefore, in the course of earlier work in these laboratories it was noted that two commercial samples of bone meal gave very different results in the soil,[1] the point was considered worthy of further investigation. It was apparent that in order to reach any reliable conclusions a wide range of bone meal samples would be required. Evidence of decomposition in storage moreover made it advisable to obtain these samples direct from commercial nurseries. As a result it was difficult to obtain any information concerning the sources and methods of preparation of the samples. This limitation was, however, offset by the knowledge that the range of samples used was truly representative of the actual materials as used in commercial practice. The importance of this point will be seen from the results, in which it is shown that the samples most readily transformed in the soil already showed signs of decomposition in storage.

The 16 samples of bone materials used in this work are briefly described in Table I. Their numerical order of arrangement is that given by the soil tests described in a later section, starting with

TABLE I

Description of Bone Meal Samples

Sample	% Nitrogen	Size of particles		Colour	Smell†
		Maximum	General		
1	4·09	2 m.m.	Much powder	Grey	° °
2	5·33	10 ,,	,, ,,	Buff	° ° °
3	3·51	10 ,,	,, ,,	Straw	° °
4	2·12	8 ,,	Mainly powder	Nearly white	°
5	5·55	4 ,,	Fine greasy powder	Pale buff	° °
6	4·32	20 ,,	Bone chips	Buff	° °
7	4·68	60 ,,	Large chips and powder	Dark brown	° °
8	4·50	10 ,,	Chips and powder	Grey	° °
9	4·10	3 ,,	Some powder	White	°
10	4·00	30 ,,	Bone chips	Dark brown	°
11	3·98	3 ,,	Fairly uniform size	Buff	°
12	4·14	4 ,,	,, ,, ,,	,,	°
13	3·78	3 ,,	,, ,, ,,	,,	°
14	3·79	3 ,,	,, ,, ,,	,,	°
15	3·79	3 ,,	,, ,, ,,	,,	-
16	4·07	3 ,,	,, ,, ,,	,,	°

† Explanation of symbols: - slight smell, ° distinct smell, ° ° strong smell, ° ° ° very strong smell.

the most readily decomposed. The samples received differed markedly in appearance, ranging from bone chips to very fine powders. In colour they ranged from almost pure white to dark brown, and while some had only a slight odour, others possessed a strong and unpleasant smell. The latter observation, recorded in the last column of Table I, gives some indication of the ease of decomposition of the materials in soil. The extreme range of nitrogen values was 2·12–5·55 per cent., the mean being 4·11 per cent. Eleven of the 16 samples had nitrogen contents within ± 10 per cent. of this mean value. Sample 4 would probably be better described as steamed bone flour. Sample 5 differed from the rest in being markedly greasy, but from its position in Table I it will be seen that, contrary to expectation, its decomposition in soil was relatively fast.

For purposes of testing in the laboratory it was necessary to pass all the samples through a high speed laboratory mill. This mill, fitted with a 1 mm. grid, produced relatively fine powders and thus removed the gross differences in particle size found in the original samples. Thus the mean percentages (± standard error) passing sieves having 30 and 40 meshes per inch were 99·1 ± 0·2 and 90·0 ± 1·9 per cent. respectively for the 16 milled samples. Subsequent investigations showed,

* A full account of this work appears in the Journal of the Science of Food and Agriculture 1951, Vol. 2, p. 125.

however, that even when milled to this extent, the particle size of the fine products was significantly related to the soluble nitrogen values and to the rates of decomposition in the soil. The following tests were made upon the milled samples:—

(1) Formation of ammonia and nitrate in the soil.

(2) Water-soluble nitrogen.

(3) Sieve analysis.

(4) Bulk-density.

(5) Distillation with an aqueous suspension of magnesia.

The experimental methods and result of the various tests are fully described in the original paper;[2] only the more important points will be summarised here.

(1) Formation of ammonia and nitrate in the soil

The bone meals were mixed with a market garden soil in amounts corresponding to a concentration of 300 p.p.m. added nitrogen and incubated for 9 days at 23·5° C. This arbitrary period of test was chosen to allow considerable but not complete decomposition. In a subsidiary experiment 13 of the samples were also tested at 200 p.p.m. of nitrogen for 7 days. The results of both series of tests are given in Table II. Values for both ammonia and nitrate nitrogen have been included,

TABLE II

Nitrate and Ammonia Formation in the Soil Tests, as a Percentage of the Total Nitrogen in Bone Meal

Sample Number	9 days test 300 p.p.m. added nitrogen			7 days test 200 p.p.m. added nitrogen		
	NH_3-N	NO_3-N	NH_3-N+NO_3-N	NH_3-N	NO_3-N	NH_3-N+NO_3-N
1	13·6	34·5	48·1	8·7	33·2	41·9
2	11·5	32·3	43·8	8·6	32·9	41.5
3	8·8	34·0	42·8	5·4	35·2	40·6
4	2·9	29·6	32·5	1·1	27·8	28·9
5	0·6	23·0	23·6	—	—	—
6	0·4	22·7	23·1	1·2	20·2	21·4
7	–0·1	20·7	20·6	—	—	—
8	0·1	18·0	18·1	0·5	15·9	16·4
9	–0·2	13·4	13·2	1·2	9·1	10·3
10	0·1	12·4	12·5	—	—	—
11	–0·1	7·8	7·7	0·6	7·2	7·8
12	0·5	6·9	7·4	0·3	6·0	6·3
13	–0·1	6·9	6·8	0·2	6·6	6·8
14	–0·1	5·8	5·7	0·3	5·2	5·5
15	–0·1	4·8	4·7	0	4·0	4·0
16	0	2·9	2·9	0·4	2·9	3·3

but it is the sum of the two which is regarded as the best measure of transformation of nitrogen.[3] Agreement between the two series is very close, a finding which supports the use of an arbitrary period of incubation in comparing rates of decomposition of a group of related nitrogenous materials. It must be emphasised that in this test, using short periods of incubation, it is the relative rates of transformation of nitrogen that are measured and not the maximum "availability." The most striking feature of the results is the great variation in extent of decomposition within the period of the test, the values ranging from 2·9 to 48·1 per cent. of the total nitrogen. It is thus clear that these samples, designated "bone meal," differ markedly in ease of decomposition of their nitrogenous constituents.

(2) Water-soluble nitrogen

The percentage of the total nitrogen soluble in water was estimated, the results being given in Table III. As in the preceding test the most interesting feature of the results was the great range of values obtained, namely from 1·0 to 50·2 per cent. A close relationship was noted between these soluble nitrogen values and the results of the soil test. Statistically there is a significant positive correlation between the two, the value of the correlation coefficient r being + 0·85. The determination of soluble nitrogen is thus a valuable guide to the ease of decomposition of the nitrogenous constituents of bone meal samples.

(3) Sieve analysis

Despite the fact that all samples were milled before testing, considerable differences were found in the fineness of the resulting powders. Thus the percentages passing the 60, 80, and 100-mesh sieves ranged from 44 to 98 per cent., 20 to 91 per cent., and 8 to 86 per cent. respectively. The results obtained with each sieve were significantly correlated with those of the soil test, values of r being + 0·80, 0·73, and 0·70 respectively. Thus the samples having the highest proportion of fine particles were most readily transformed to ammonia and nitrate in the soil; they also showed the highest figures for water-soluble nitrogen. Such findings are in accord with expectation in view of the high surface area of fine particles. It was later found however that the simple physical explanation is complicated by chemical differences between particles of different size, and the subject is further discussed in a later section of this report.

(4) Bulk-density

The volume occupied by a known weight of milled bone meals was measured and the results, expressed in grammes per cubic centimetre, are recorded in Table III. Despite the simplicity of this test, the results are again related to those of the soil test. In this case however the correlation is a negative one, $r = -0{\cdot}62$, and high values in the soil test correspond to low bulk densities. The bulk

TABLE III

Results of Tests on 16 Samples of Bone Meal

Sample Number	* % Water-soluble nitrogen	* % NH_3-N (MgO)	Sieving Analysis % Passing Sieves			Bulk-density g./c.c.
			60-mesh	80-mesh	100-mesh	Sieved
1	19·4	4·20	98·1	91·2	86·3	0·72
2	35·5	14·14	73·3	56·9	50·1	0·90
3	50·2	4·37	96·4	86·1	79·7	0·82
4	19·5	0·56	83·1	73·0	67·9	0·79
5	6·7	0·40	58·4	19·6	7·5	0·61
6	13·4	2·10	80·0	64·5	58·9	0·89
7	16·6	1·47	83·7	67·9	60·9	0·81
8	9·2	2·95	74·8	59·7	53·1	0·75
9	1·7	0·98	74·1	55·4	48·5	0·91
10	7·0	2·15	69·4	52·2	46·2	0·92
11	5·9	4·63	58·1	42·5	37·0	0·89
12	3·5	0·82	59·6	41·1	35·4	0·97
13	3·1	1·81	61·2	41·6	34·4	1·04
14	5·1	1·40	68·9	51·4	45·5	0·98
15	1·3	0·61	44·5	30·6	26·3	0·96
16	1·0	0·50	45·0	32·0	27·8	1·01
Standard error	0·3	0·03	—	—	—	0·008
Significant difference P — 0.05	1·0	0·09	—	—	—	0·02

* Water-soluble nitrogen and ammonia-nitrogen expressed as percentage of the total nitrogen.

density of a powder is a somewhat arbitrary measurement, influenced by the experimental methods employed. It depends on a number of factors, including the true density of the material, its internal pore space, and the size and packing of the particles. For a given type of material a negative correlation would be expected between sieve analysis and bulk density. Provided that sample 5 is omitted this is in fact the case here; the greasy nature of this sample, which prevents close packing of the particles in the bulk density tests, also hinders passage through the finer sieves and thus gives a marked exception to the relationship found for the other 15 samples.

(5) Distillation with an aqueous suspension of magnesia

This test provides a measure of the ammonia and readily-decomposed nitrogenous compounds present in the samples. Fifteen of the samples yielded between 0·4 and 4·6 per cent. of their nitrogen as ammonia in this test, while the remaining sample, No. 2, which has a strong and unpleasant smell, gave the relatively high value of 14·1 per cent. If this latter value be omitted the correlation between these results and those of the soil test fails to attain significance. The results do however indicate

that decomposition can occur in the stored materials. Such samples are attractive to insects, of which a moth *Tineola bisselliella* Hum., and a beetle, *Ptinus tectus* Bld., have been identified. Following an earlier observation that the nitrogen content of one sample of bone meal decreased in storage, examination of sample 2 showed the presence of numerous fungi, and several bacteria were isolated in pure culture which were able to liquefy gelatin. The fact that a closer correlation between the soil tests and ammonia liberated by magnesia distillation was not found, despite the presence of suitable organisms for decomposition, is probably due to the loss of ammonia from the bone materials in storage.

Effect of particle size on the tests

In view of the importance of differences in particle size even after milling, further tests were made with different sieved fractions of the milled products. This work was, however, complicated by the fact that the total nitrogen content of these different fractions varied considerably, being highest in the coarser fractions. Thus for sample 10 total nitrogen values ranged from 4·39 per cent. in the 20—30 mesh fraction to 3·10 per cent. in the fraction passing a 100-mesh sieve. Similar results were obtained with samples 6 and 16, showing that not only the particle size but the composition of the different sieved fractions varied. The magnitude of the effect is shown for sample 6 in Table IV, in which the total nitrogen content of three sieved ranges of particle size are given together with the percentage of this nitrogen soluble in water and transformed to ammonia and nitrate within a period of six days in the soil. In both the latter tests the different sieved fractions showed widely different values, the nitrogenous constituents of the coarsest fractions being least soluble and least available in the soil test.

TABLE IV

Tests on Different Sieved Fractions of Bone Meal Sample 6

Sieve range	% Nitrogen	Soil test* NH_3-N+NO_3-N	Water soluble* nitrogen
10—20 mesh	5.37	8.3	2.2
40—60 „	4.24	23.9	17.3
100 „	3·57	32·1	29·4

* Expressed as percentage of the total nitrogen.

To find the effect of differences in particle size without variation in chemical composition, further batches of bone materials were milled completely through grids having the following apertures: 2·2, 1·0 and 0·6 mm. In this way samples of approximately constant total nitrogen content but containing different ranges of particle sizes were obtained. The results of tests with samples 6, 8 and 12 are given in Table V. Despite considerable differences in particle size, the sub-samples from any one bone meal showed a relatively small variation in response to the different degrees of milling. It therefore appeared that, although there is some increase in soluble nitrogen and ease of decomposition in the soil as the result of milling, the wide differences shown in Table IV must be ascribed to some other cause, namely to differences in composition of the various sieved fractions. That bone meals may be markedly heterogeneous is shown by the total nitrogen values as in Table IV. The softest portions will by grinding and sieving be concentrated in the finest fractions, and it is these which show high values for soluble nitrogen and the soil test. Apart from differences due to extraction of fat or steaming, bone meals may be expected to differ in composition, containing for example varying amounts of marrow and adhering cartilage. Thus the sieve analyses of the original 16 bone meals, previously shown to be significantly correlated with the soluble nitrogen and soil tests, may be taken as a rough measure of the amount of relatively soft material present. From the coarse material of sample 10 prior to milling it was possible to separate by hand two fractions of different appearance. Of these, one consisted of hard white bone chips (I), the other of softer and less regular pieces having a darker colour (II). On milling these separately to pass a 60-mesh sieve it was found that fraction II contained approximately 6 times as much soluble nitrogen as fraction I. The water soluble nitrogen of a sample of bone meal may thus be largely attributed to its content of soft and soluble material, and not regarded as a measure of the solubility of a homogeneous substance. Where, as in Table V, sub-samples are prepared by different degrees of milling without separation of the products by sieving, the chemical composition is roughly constant and variation in soluble nitrogen values is relatively small. The recorded differences in sieve analysis in this Table are probably due to hard bone material, the milling of which has a relatively small effect on the total solubility of the sample.

TABLE V

TESTS ON BONE MEALS MILLED THROUGH THREE DIFFERENT GRIDS

Test	Sample Number							
	6			8			12	
	Grid on mill (m.m)							
	2·2	1·0	0·6	2·2	1·0	0·6	1·0	0·6
Total nitrogen (%)	4·50	4·41	4·20	5·09	4·97	4·97	4·07	4·05
Soluble nitrogen (% of total N) ...	10·3	13·0	13·9	7·0	6·4	7·0	3·6	3·8
Soil test. (NH_3-N + NO_3-N%) ...	17·6	22·1	23·1	17·7	17·1	18·1	5·9	7·4
Sieved bulk density (g./c.c.)	0·90	0·88	0·81	0·83	0·86	0·83	0·93	0·90
Sieve analysis. % passing mesh 10 ...	100·0	—	—	100·0	100·0	—	—	—
,, ,, ,, ,, ,, 20 ...	93·4	100·0	100·0	94·0	99·9	—	100·0	100·0
,, ,, ,, ,, ,, 30 ...	73·9	97·5	99·9	71·7	97·2	100·0	99·4	99·9
,, ,, ,, ,, ,, 40 ...	56·8	86·4	98·7	51·2	80·1	97·9	89·6	97·9
,, ,, ,, ,, ,, 60 ...	39·2	60·4	87·7	30·4	53·3	79·3	63·6	71·8
,, ,, ,, ,, ,, 80 ...	26·8	45·5	70·3	21·4	37·5	60·1	45·4	52·3
,, ,, ,, ,, ,, 100 ...	25·4	39·3	59·3	18·2	31·5	51·8	39·0	45·0

Conclusions

From the full results of the various tests it was concluded that water-soluble nitrogen was the most valuable single guide to the rate of decomposition of the samples in soil. By combining the results of this chemical test with a simple physical test such as bulk density or sieve analysis an even closer relationship could be shown. Thus in Fig. 1 the experimental values in the 9 day soil test are plotted against those calculated from the soluble nitrogen and bulk density determinations. Actual values of the multiple correlation coefficients between the soil test and the soluble nitrogen taken together with either bulk-density or sieve analysis were 0·92 and 0·89 respectively. It must however be emphasised that all the results refer to samples milled in the laboratory.

From the standpoint of the practical grower it is clear that the term "bone meal" is commonly used to denote substances differing widely in composition and properties. Of the materials here described samples 11 to 16, the nitrogenous constituents of which are least soluble and most slowly decomposed in the soil, can be regarded as relatively fresh samples such as might normally be obtained from an established supplier. These samples had a relatively constant nitrogen content of about 4 per cent., and were of a uniform grist, containing neither large bone chips nor much fine dust. More rapid results would be expected from these samples after storage, during which the particles become less hard and may be loosely matted together as the result of biological changes. Though the present results refer mainly to the nitrogen of bone meal, investigation of the phosphatic constituents is planned at a later date.

Grateful acknowledgements are made to all those who so kindly provided the samples used in this investigation.

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2. STEAM STERILIZATION STUDIES

By J. N. DAVIES and O. OWEN

Investigations on the production of ammonia and nitrate following steam sterilization of soil have been continued.

Three different methods of partial sterilization have been used. One was the well-known Hoddesdon pipe system used in the houses as normally carried out under commercial conditions. The second consisted of passing steam under pressure into soil in glazed earthenware jars in the laboratory. The third consisted of heating quantities of soil in plugged flasks so that the samples could be incubated undisturbed and uncontaminated until sampling for analysis took place.

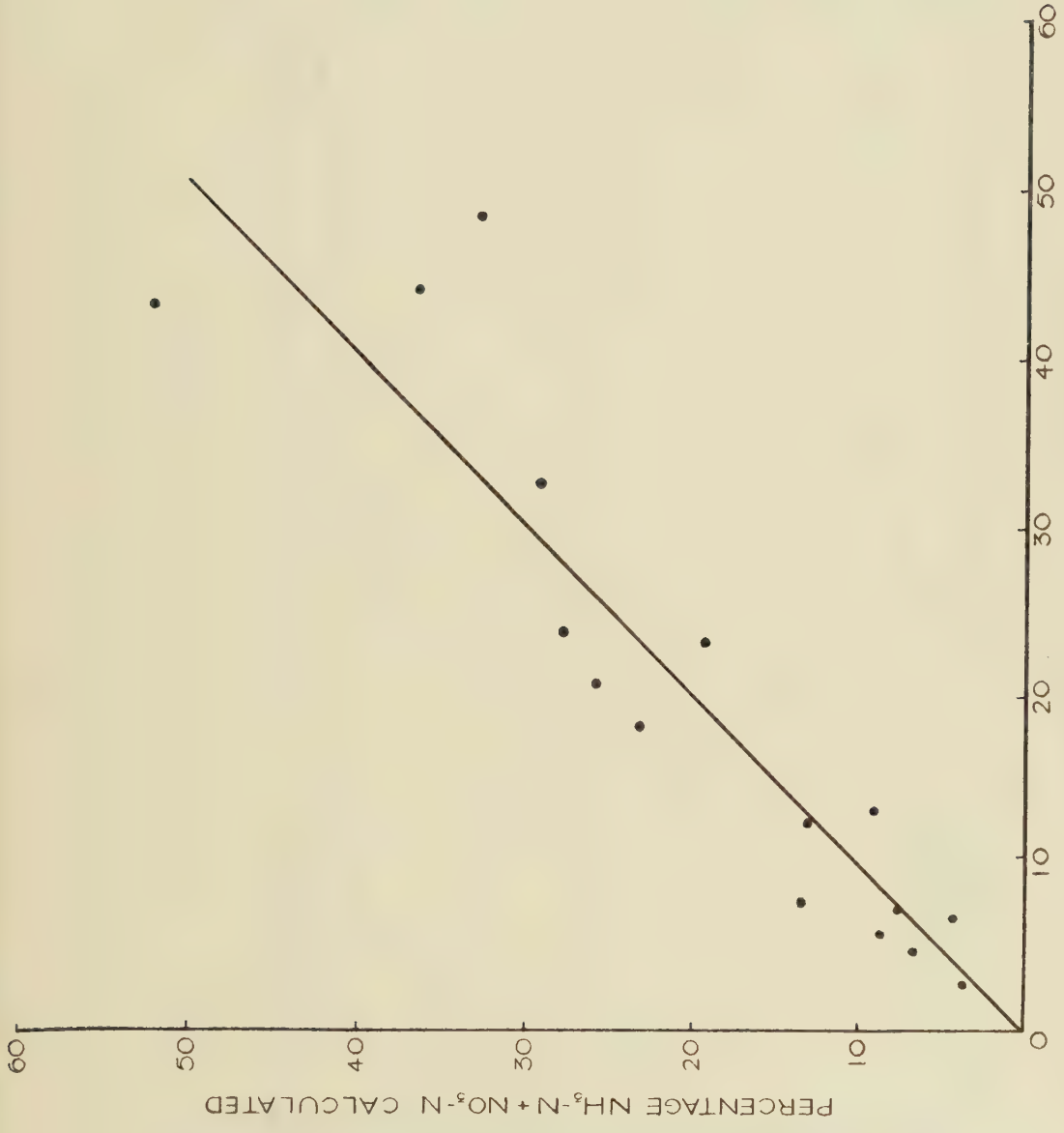

FIG. 1

Correlation between experimental values for 16 samples of bone meal in the nine-day soil tests and calculated values from the multiple regression equation based on water-soluble nitrogen and sieved bulk-density of the milled samples.

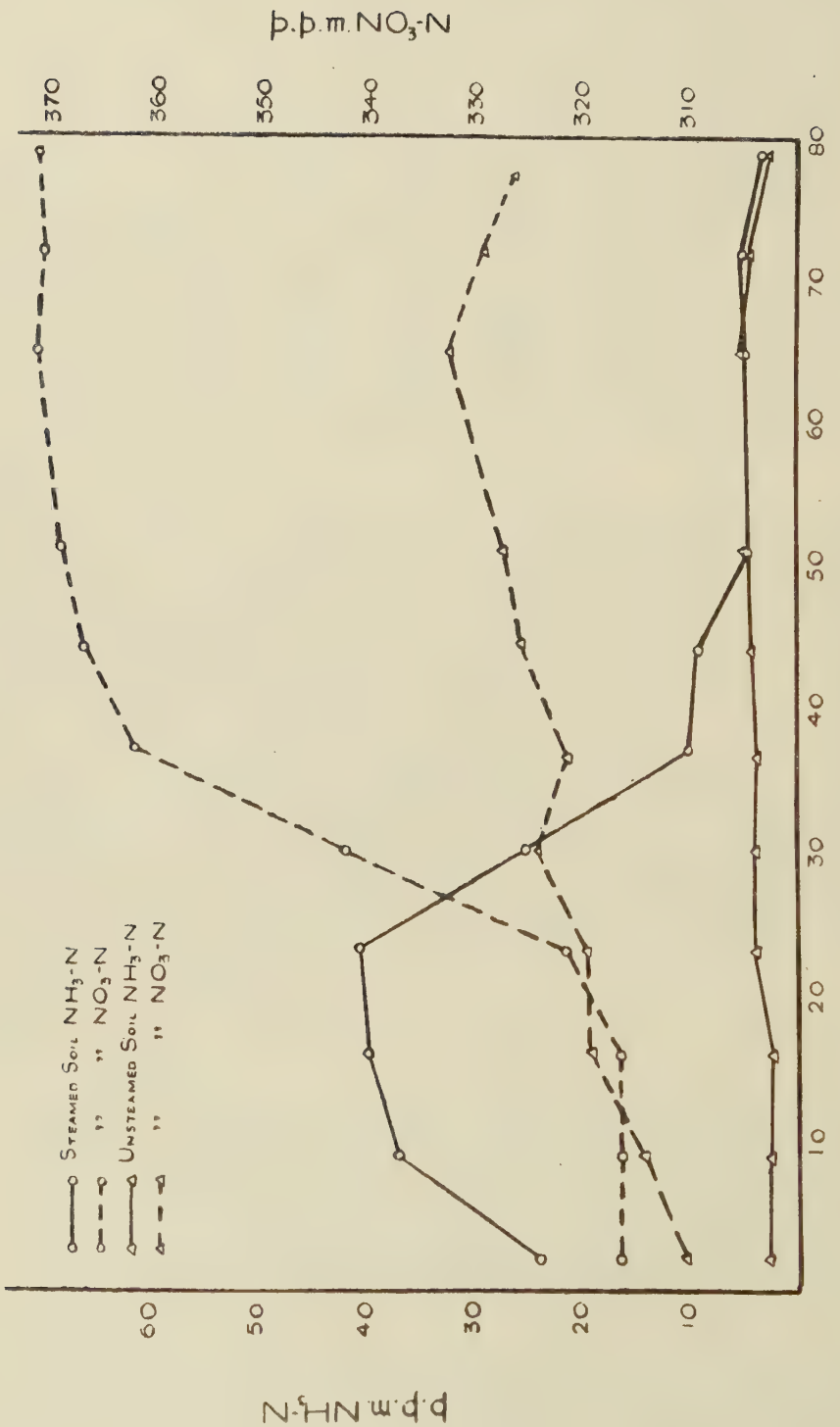

Fig. 1

Fluctuations in ammonia and nitrate in an old cucumber soil after steaming (incubated).

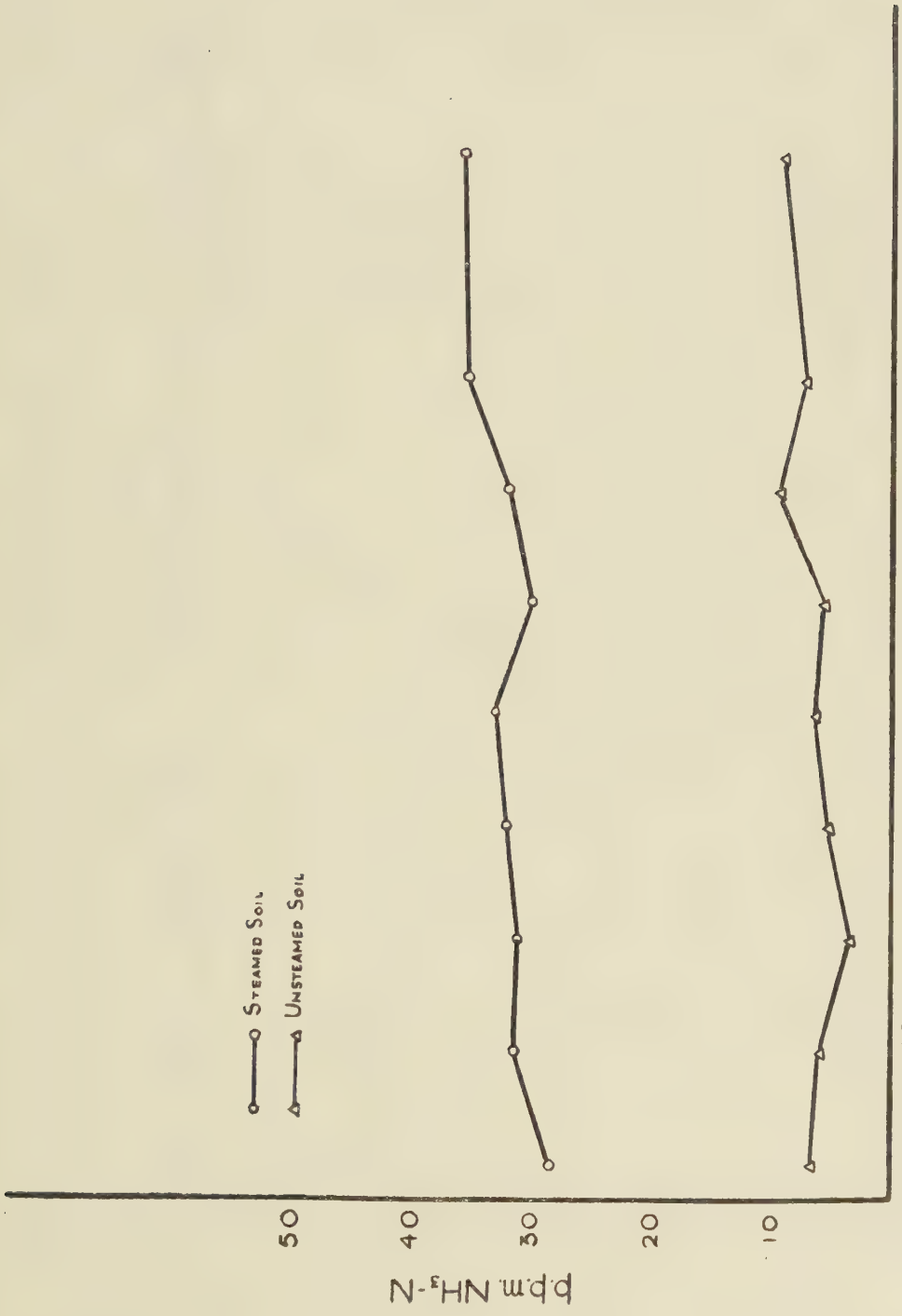

Fig. 2

Fluctuations in ammonia values in an old cucumber soil (sampled *in situ*).

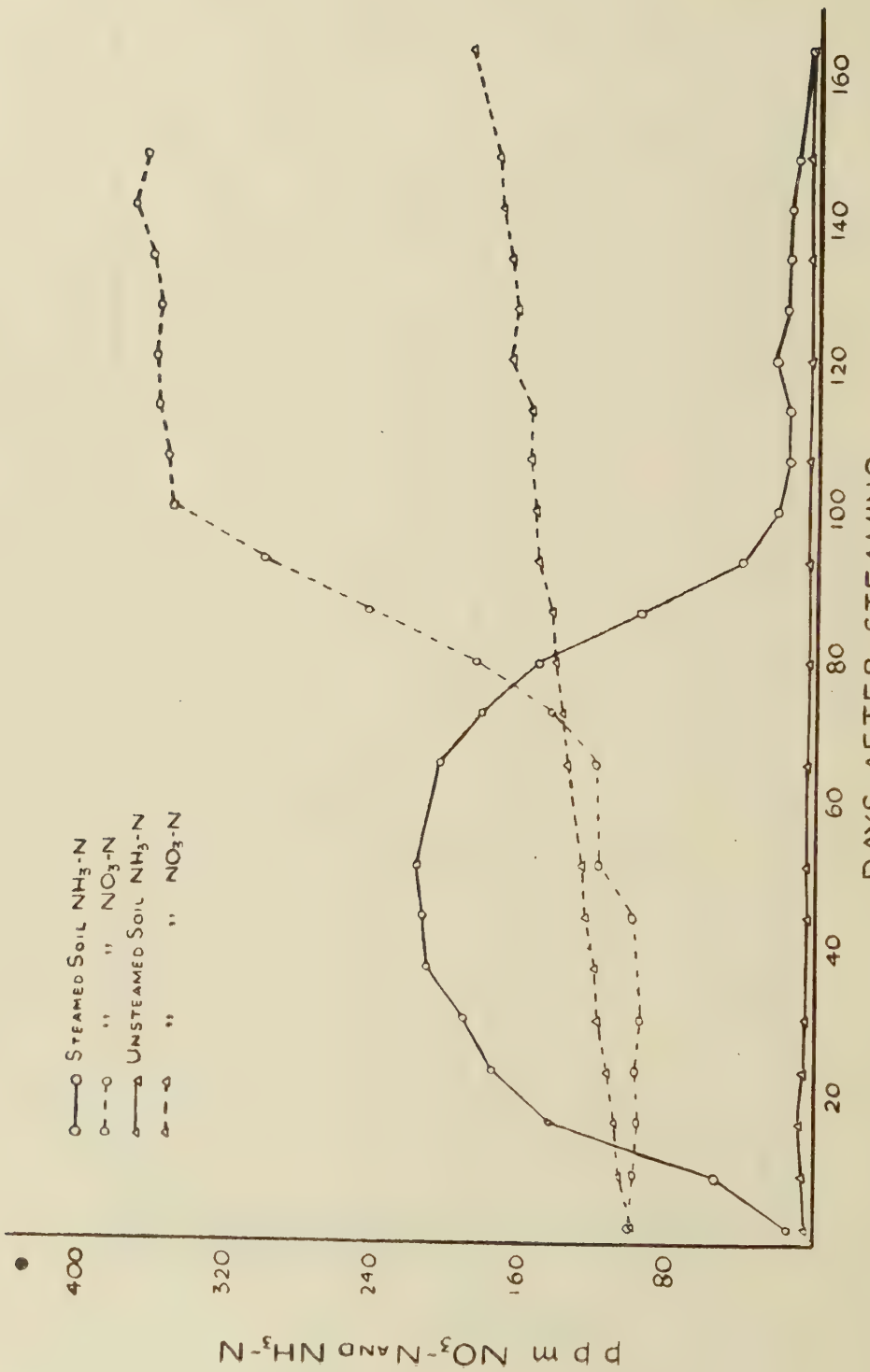

Fig. 3

Fluctuations in ammonia and nitrate in a maiden loam after steaming (incubated).

A number of different soils have been used at different times and the results for typical soils will be given. The first was the soil from an old cucumber base which had been in cultivation since 1927. It contained 0·46 per cent. nitrogen and 4·15 per cent. organic carbon giving a carbon/nitrogen ratio of 9. It is estimated that since cultivation started this soil has retained something of the order of 3,600 lbs. of nitrogen per acre of bed. Ammonia and nitrate production in this soil were followed under two different sets of conditions. After steaming by the Hoddesdon pipe method a bulk sample was taken and incubated in earthenware jars at 23·5° C. Periodically the soil was turned out of the jars for mixing and a representative sample taken for analysis. The fluctuations in ammonia and nitrate values are shown in Fig. 1.

From Fig. 1 it will be seen that at no time did ammonia in the unsteamed soil exceed 5·3 p.p.m. In the steamed soil, on the other hand, the concentration had risen to 24 p.p.m. within 2 days and reached a maximum of 40 p.p.m. on the twenty-third day. Turning to the nitrate values in the same figure, the initial value was high at 310 p.p.m. and in the unsteamed soil it rose to over 330 p.p.m. after 65 days. In the steamed soil nitrate remained stationary for 16 days after which it began to rise. After the twenty-third day it rose rapidly, eventually attaining a maximum of 370 p.p.m. on the sixty-fifth day. A striking feature is the rapidity of the fall in ammonia concentration once nitrification had started.

When the soil in the actual border was analysed after steaming the results are quite different. Those for ammonia are shown in Fig. 2. The values for nitrate have been omitted for the sake of simplicity.

From Fig. 2 it will be seen that here the ammonia concentration increases rapidly after steaming and fluctuated between 30 and 36 p.p.m. until the sixty-fifth day. After this the fluctuations continued and 135 days after steaming it was 49·5 p.p.m. when the concentration in the unsteamed plot was 4·8 p.p.m. During this period the fluctuations in nitrate values in both of the plots were extremely wide, limits being 325 and 479 p.p.m. in the unsteamed plot, and 316 and 422 p.p.m. in the steamed. These fluctuations are normal for this type of soil and are presumably unrelated to the extra ammonia produced as a result of sterilization.

It is interesting to compare the foregoing with results for a maiden soil of similar carbon and nitrogen contents. It was bought for propagating soil but proved far richer than usual. Total nitrogen was 0·51 per cent. and organic carbon 4·55 giving a carbon nitrogen ration of 9. The ammonia and nitrate fluctuations are shown in Fig. 3 which may be compared with Fig. 1.

From Fig. 3 it will be seen that the ammonia in the unsteamed control soil remained at a very low level throughout. After steaming, however, ammonia concentration increased steadily to a maximum concentration on the fifty first day, after which it fell steadily till the hundredth day. During this time nitrate was increasing gradually in the unsteamed soil.

In the steamed soil nitrate was relatively steady up to the forty fourth day after which there was a slight rise. From the sixty fifth day it rose rapidly to almost the maximum on the hundredth day.

In this soil changes in nitrate plus ammonia production persisted for 51 days whereas in the old cucumber soil they were complete to all intents and purposes in 9 days. This difference is attributed to effects of repeated previous steaming of the cucumber soil and this possibility is dealt with later in this report.

A soil of quite different composition and history was next examined. This was an old tomato soil with a nitrogen content of 0.35 per cent. and carbon content of 2·93 per cent. giving a carbon/nitrogen ratio of 8·4. This soil was steamed in the house in the usual way. A bulk sample was incubated and at the same time samples from the house were analysed periodically. The results for the incubated soil are shown in Fig. 4.

Here the concentrations were much lower than in the previous soils. There was a relatively rapid accumulation of ammonia which reached a maximum in 12 days, after which it fell and to all intents and purposes the ammonia concentration was the same as in the unsteamed soil after 33 days. The nitrification curve suggests that there had been some denitrification immediately after steaming as values were reduced during the first 19 days. Nitrification did not start until after the ammonia concentration fell but was fairly rapid thereafter, nitrate concentration increasing from 19 p.p.m. to 58 p.p.m. in a matter of 14 days, eventually reaching 63 p.p.m. on the forty seventh day.

Results for the soil in the same plot but sampled *in situ* are shown in Fig. 5.

Values for ammonia are of the same order as those in Fig. 4. Here, however, accumulation of ammonia persisted for much longer and a maximum was not reached until after 50 days. Again nitrate values are lower in the steamed soil, suggesting denitrification. When nitrification did start it developed fairly rapidly.

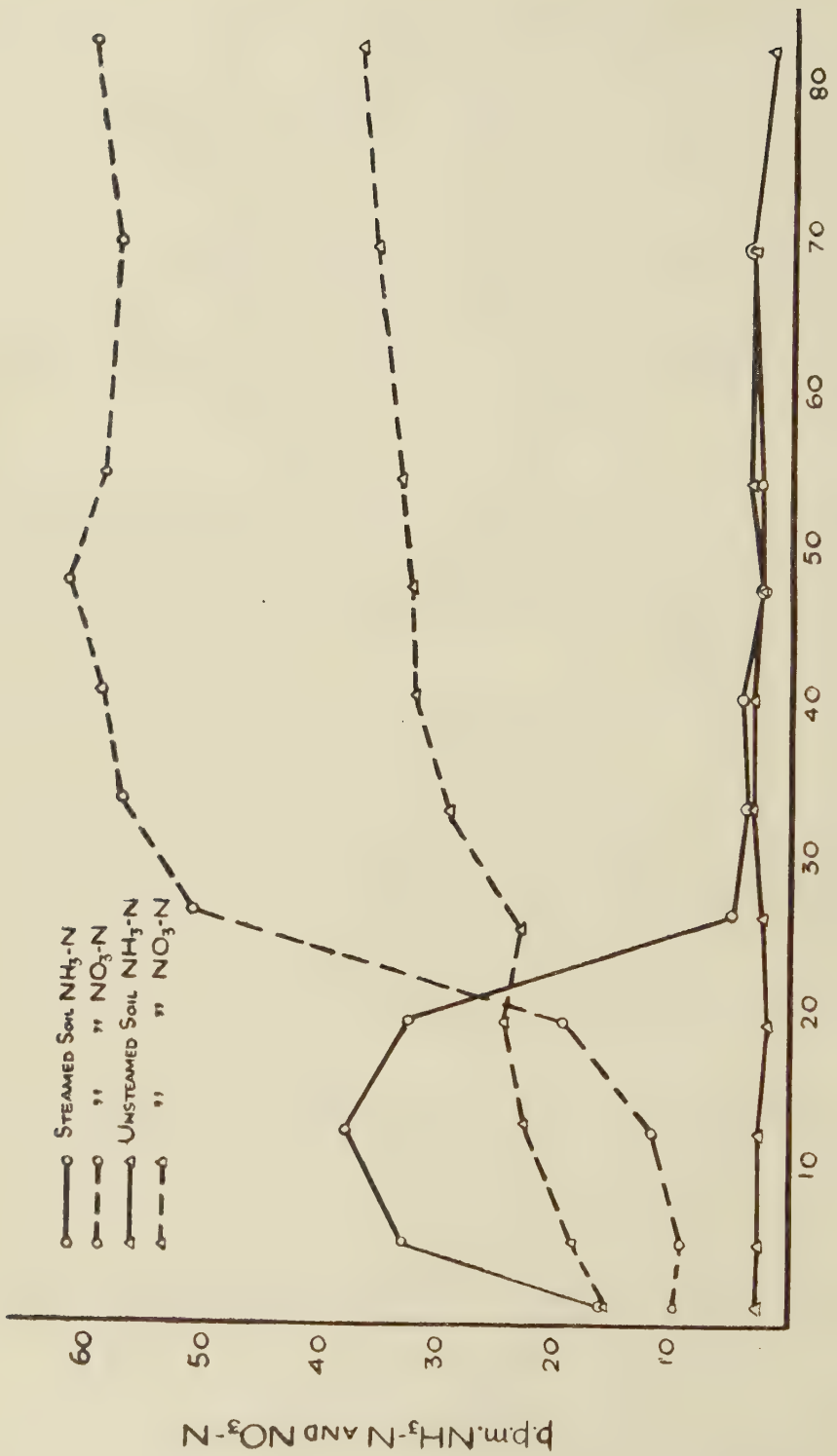

Fig. 4

Fluctuations in ammonia and nitrate in an old tomato soil after steaming (incubated).

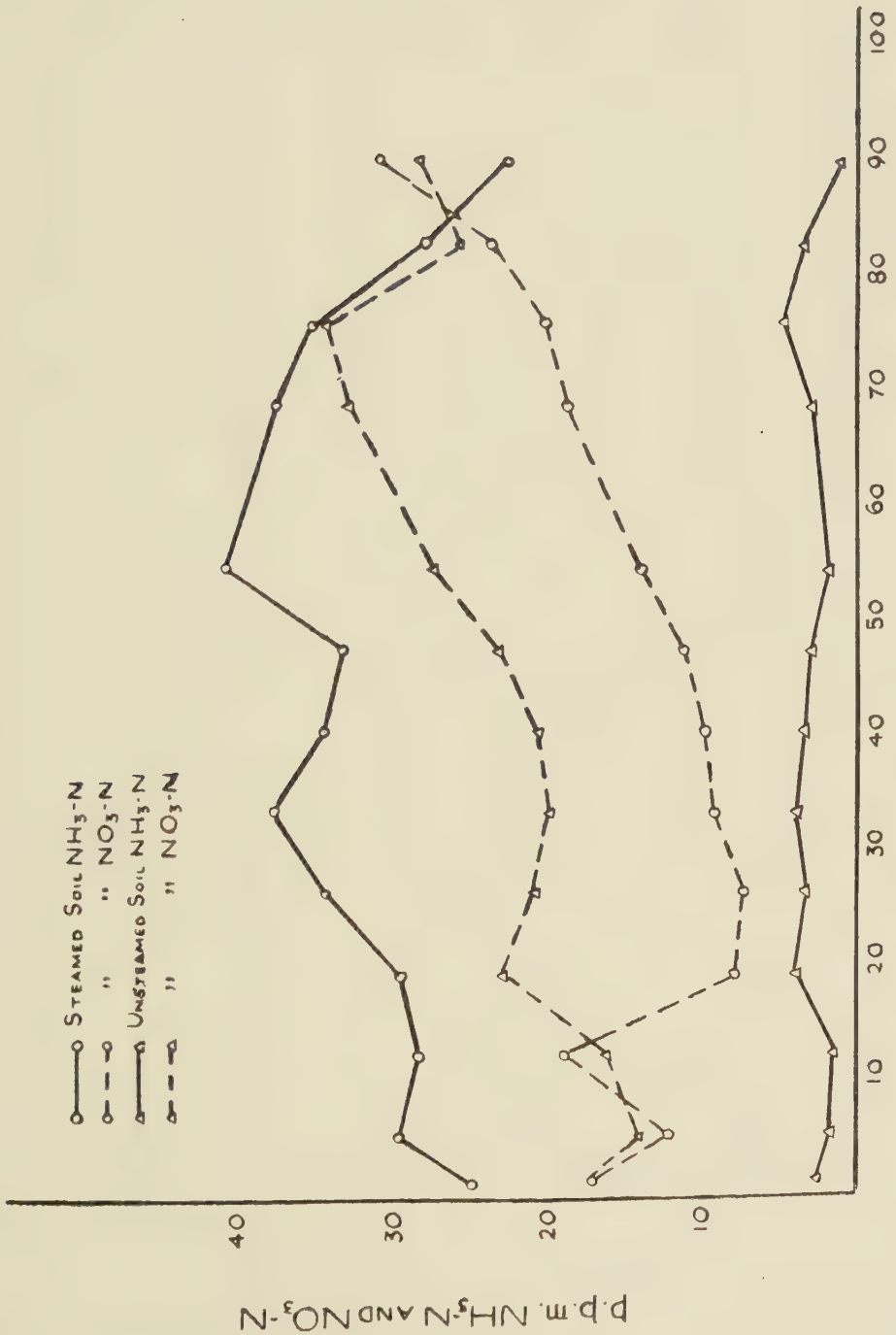

Fig. 5
Fluctuations in ammonia and nitrate in an old tomato soil (sampled *in situ*).

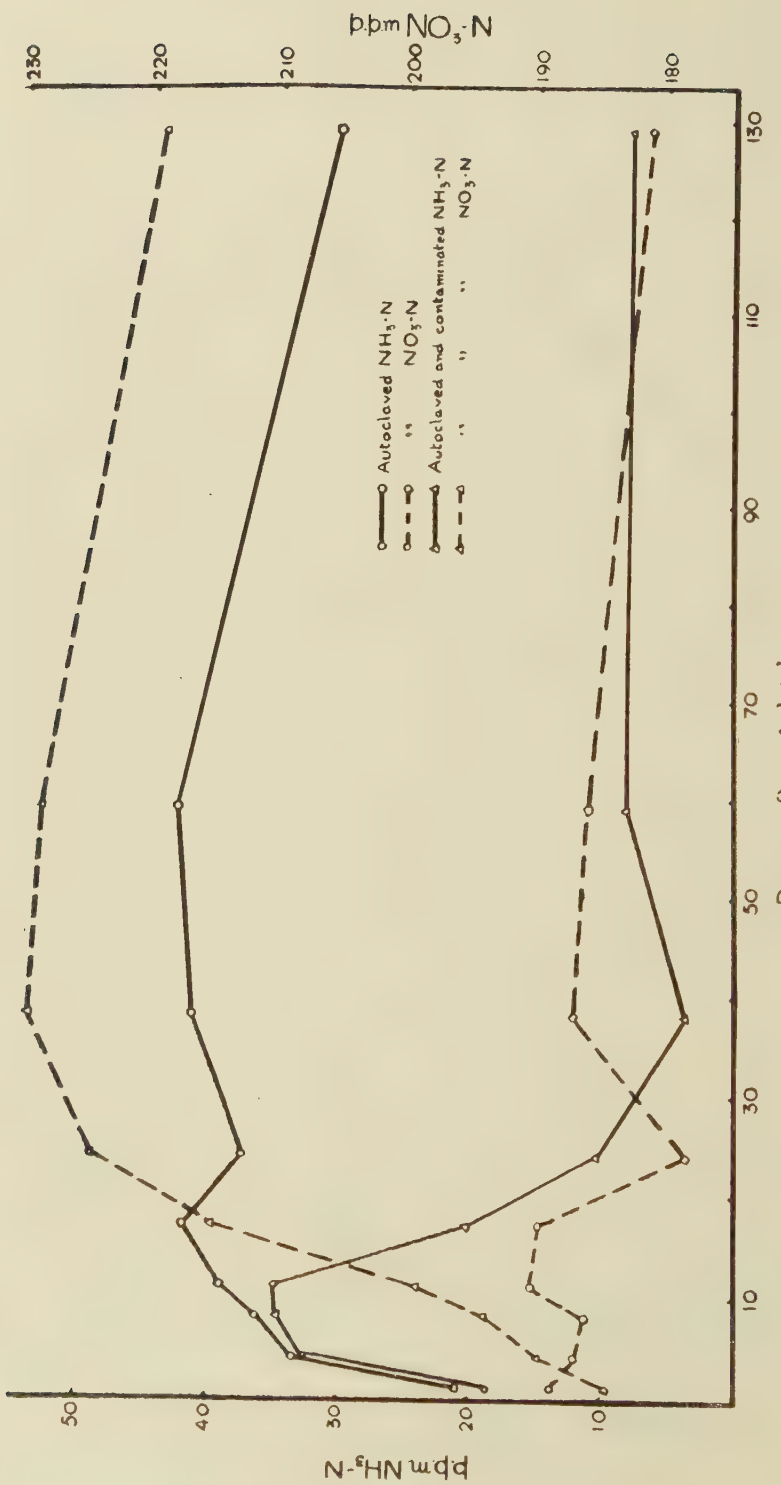

Fig. 6
The effects of contaminating a steamed soil

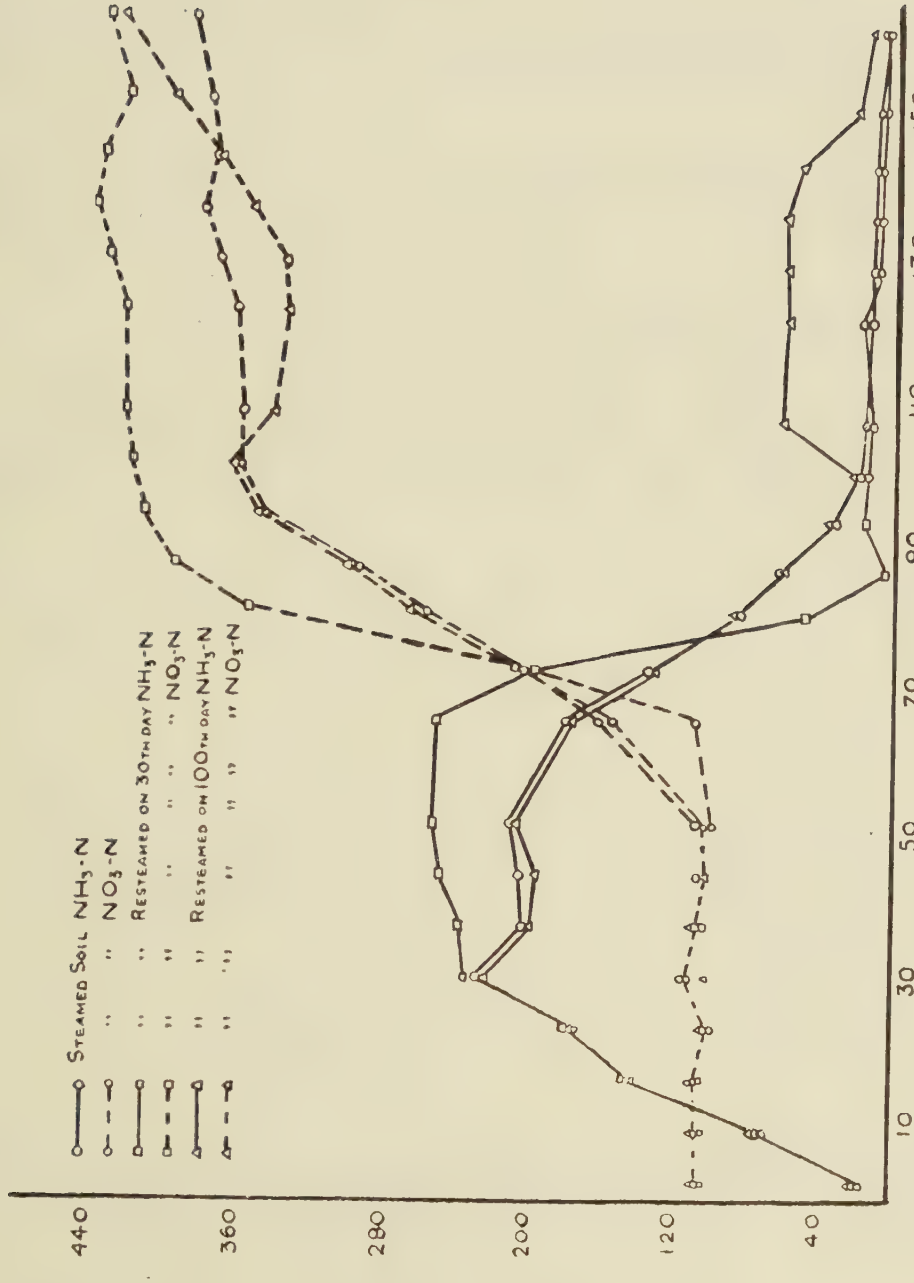

Fig. 7

The effects on ammonia and nitrate of resteaming after (i) 30 days (ii) 100 days.

The effects of contamination

A number of experiments have been carried out to determine the effects on ammonia and nitrate production when the steamed soil is deliberately contaminated immediately after steaming with unsteamed soil. The results of one such experiment which is typical are shown in Fig. 6.

The soil used was old cucumber bed and the changes were followed using the flask technique in which adventitious contamination is obviated. The contamination was effected by introducing into each flask 2 ml. of a suspension of 50 g. unsteamed soil in 500 ml. of water. It will be seen from Fig. 6 that the effect of contamination is to hasten deammonification and nitrification.

The effects of re-steaming

In commercial practice the question is often raised concerning the effects of repeated steaming of the same soil at different times. To a limited extent an attempt has been made to answer this question by experiments carried out on the maiden loam already studied. Three different batches of this soil were steamed by the lab. method and incubated in jars. The concentrations of ammonia in all three batches were sensibly the same until the thirtieth day when values for all three were well over 200 p.p.m. The ammonia production had clearly followed the same course as that already shown for the same soil in Fig. 3. On the twenty ninth day one batch was resteamed. This caused only a slight increase in ammonia concentration but this concentration was maintained for 36 days. During that time no nitrification had set in whereas in the other two batches ammonia concentration was falling and nitrification had started. So that the position was that after 36 days in the resteamed soil ammonia was some 80 p.p.m. higher and nitrate some 55 p.p.m. lower as the result of the treatment. After this time, however, deammonification developed rapidly with the result that in 21 days the ammonia concentration had fallen by 250 p.p.m. while during the same period nitrate had increased by 287 p.p.m.

As will be seen in Fig. 7 changes proceeded normally in the other two batches of soil until the hundredth day from the commencement of the experiment, when it was considered that ammonia concentrations were a minimum. One of these batches was then resteamed with the result that the ammonia increased by 49 p.p.m. and nitrate was reduced. On four separate sampling days nitrate was lower after the resteaming and on five sampling days the ammonia was significantly higher.

Discussion and conclusions

As was expected results now presented are entirely in accordance with the well-established fact that one of the effects of steaming is to increase ammonia production in soil. What is not appreciated however is that when steaming takes place under glass and the soil is undisturbed, ammonia production continues for a considerable time and nitrification does not occur. It is still problematical as to when nitrification does commence and what agencies are responsible for its inception. On the other hand when the steamed soil is mixed and so exposed in the laboratory ammonification reaches its peak comparatively quickly and nitrification sets in quite soon. At first sight it would appear that contamination occurs in the laboratory and brings about the changes observed. While this may be the explanation it must be remembered that in the houses after steaming, the soil is exposed to any aerial infections which may be present. In addition there is often repair work going on in the houses and on the structure so that there appears to be abundant opportunity for contamination to take place. The fact remains, however, that nitrification in the main body of the soil does not occur for some considerable time.

It is frequently maintained that an important contribution to the toxicity of steamed soil is made by the ammonia produced during sterilization. The ammonia values for the maiden soil depicted in Fig. 3 dispose of this possibility. As has been shown a value of 217 p.p.m. ammoniacal nitrogen was recorded in this soil, despite the disturbances due to sampling. If the soil has not been disturbed in this way it is probable that even higher values would have developed. In spite of this the soil has in fact been steamed and extensively used for the propagation of tomatoes, cucumbers and other species without any untoward effects.

The results of the contamination experiments have a practical interest. For many years it was common practice to sterilize soil by baking and it is probable that occasionally the soil was overheated and became sterile. As an inevitable consequence of this poor growth of seedlings occurred. Growers found that the addition of some virgin soil corrected this undesirable condition. Clearly they were inoculating the sterile propagating medium. There was, of course, always the risk of introducing pathogenic organisms but despite the warnings of the plant pathologist the practice persisted for some time. In recent years however this has rarely been necessary since steaming has replaced baking to a

large extent. What was not apparent at the time, however, was that this deliberate contamination must have had the additional effect of reducing the actual ammonia concentration and of hastening its disappearance. As has already been pointed out the ammonia would not have had any harmful effect on seedlings but it is always possible that the persistence of high ammonia values in the soil has undesirable effects on the vigor and constitution of the plant later on in their life.

The experiment on resteaming suggest that as measured by the effects on ammonification and nitrification a second steaming of the soil 30 or 100 days after the first is nothing like so effective. At the same time there is the suggestion that the final levels of nitrate produced are the same in all three cases. This conclusion probably explains the decided difference in behaviour of the old cucumber soil and maiden loam after steaming.

There is the suggestion in some of the experiments that ammonia production is accompanied by denitrification and it would appear that this may occur even when aeration may be considered to be quite adequate.

3. THE EFFECTS OF SOME ACUTE MINERAL DEFICIENCIES ON GLASSHOUSE CHRYSANTHEMUMS

By J. H. L. MESSING and O. OWEN

The work on chrysanthemums which was commenced in 1949 has been continued. The number of varieties used was extended to 14 and the elements consisted of boron, manganese and potassium. A departure from previous practice was the use of water demineralised by the "Deminrolit" system for making up the culture solutions. As was expected water treated in this way proved quite satisfactory where the omission of potash and manganese were concerned but it was unsuitable for the solutions from which boron was omitted. In this latter case only mild effects of the omission were produced and where the use of the water was continued they disappeared in time and apparently normal growth occurred. When however, distilled water was substituted the effects of the boron deficiency became pronounced within 14 days and became acute in a comparatively short time.

The main conclusions to be made are similar to those of last year. In general the effect of any one of the deficiencies depends on the variety studied and the acuteness of the effect depends to a considerable extent on the stage in the life of the plant at which the deficiency becomes operative.

The varieties used, and the deficiencies studied were:—

1.	Sussex Bronze (Bronze reflexed)	Boron, manganese, potassium
2.	Sussex Red (Red reflexed)	Boron
3.	Sussex Pink (Pink reflexed)	Boron, manganese
4.	Rose Harrison (Pink reflexed)	Boron, manganese
5.	Imperial Pink (Pink reflexed)	Potassium
6.	Autocrat (White semi-incurved)	Boron, manganese, potassium
7.	Market Gold (Amber Gold reflexed)	Potassium
8.	Friendly Rival (Bright Yellow incurved)	Boron
9.	Monument (White incurved)	Boron, manganese
10.	Penrod (Yellow incurved)	Boron
11.	Blazing Gold (Yellow incurved)	Boron
12.	Annette (White reflexed)	Boron
13.	Edith Alston (White reflexed)	Boron
14.	Edith Alston (White incurved)	Boron

Cuttings of varieties 1 to 7 from our own stock were rooted in sand. The other varieties were established in soil in accordance with standard commercial practice. Nos. 8 and 9 were transferred to sand in March and the remainder in early April.

The omission of boron

The effects on flowers

Last year it was reported that the omission of boron caused the flower petals to curl upwards so that a variety normally reflexed tends to become incurved. This year this observation was confirmed and the phenomenon studied in more detail. Not only are the shapes and conformation of petals seriously affected but it appears that the white varieties show pronounced susceptibility. As there is considerable variation in the shape of the petals of different varieties it will suffice to describe the

effects on one, namely the white reflexed Edith Alston, in which they were probably most pronounced.

The petals of this variety grown normally are more elaborate than those of many other varieties. In particular the tubular part at the base of the petal is quite distinct which is somewhat uncommon. Ordinarily the tubular part leads to a funnel-shaped lobe which may be up to 5 mm. in length. Where boron is omitted the "funnel" is reduced in length or may be non-existent and the tube also is considerably shortened. The texture of the florets is appreciably altered. Instead of the sheen and smoothness of normally nourished petals the surfaces become dull and rough almost to the point of irregular corrugation. Another striking feature is a high susceptibility to bruising. Normal petals turn grey and tend to become transparent at the point of contact. In the absence of boron however the bruised part becomes brown in a matter of minutes. This is no doubt related to the enzyme status of the plant and it is hoped to investigate this later. Individual petals tend to curl upwards and inwards so that the overall effect on the bloom as a whole is to make it perfectly incurved.

Similar effects were observed on the other reflexed varieties where the operative times of boron omission were adjusted to make flower formation possible. Where the boron was omitted too early in relation to flower formation insufficient development took place to make the general effects possible.

When the varieties which are normally incurved were subjected to this treatment effects on the texture of petals was the same. In this connection it may be stated that effects on petals of incurved Edith Alston were the most pronounced in the whole series. The overall effects were a much "tighter" flower, due partially to closer packing of the petals and partially to the fact that individual petals were often smaller.

The effects on foliage

The effects are governed mainly by the variety studied and by the time at which the omission became operative.

In the case of Rose Harrison, where the plants were maintained in a vegetative condition by removal of the flower buds at an early stage the top leaves show chlorosis and gradually lose colour so that eventually they are very pale yellow. Internodes becomes very short and leaves tend to assume a vertical habit. Where buds were allowed to develop, however, the effects are different. The first and most striking effect is that leaves show considerable distortion and they curl downwards and inwards. Leaves may grow to an appreciable size but are very brittle so that they break off the stem very easily. The veins become brown and crack at various points. Irregular interveinal chlorosis occurs and areas become red or brown and finally die.

The varieties Monument and Autocrat react in the same way to boron deficiency. Colour of the young leaves is only slightly affected and internodes are extremely reduced. Leaves tend to hang downwards and are very brittle. Irregular chlorotic areas appear and veins crack. Where the deficiency operates early flower buds do not develop but die without opening.

The effects on the foliage of both reflexed and incurved Edith Alston were not so pronounced as those recorded for the preceding varieties. The shortening of internodes was not so acute particularly on the incurved variety, there was only a limited loss of colour and the cracking of the veins did not occur until late in the season.

Except for some reduction in size of leaves and strength of the stems there were no outstanding effects on the foliage of Annette or of Penrod.

All the foregoing varieties were maintained under glass during the whole year. The others were kept out of doors during the summer months and solutions made up in demineralised water. Of these Sussex Bronze, Sussex Red and Sussex Pink were not noticeably affected. Growth in Autocrat was much reduced and the size of the blooms reduced. The foliage of Friendly Rival was not affected but the blooms were smaller and the texture of the petals showed the characteristic effects. No symptoms were observed on the foliage of Blazing Gold but the effects on the blooms were apparent, in that they were slightly paler in colour and the petals were packed more tightly.

The omission of manganese

In this series Rose Harrison and Monument were kept under glass during the whole season but Sussex Bronze, Sussex Pink and Autocrat were kept outdoors in accordance with standard commercial practice during the summer months. All five varieties were treated with culture solutions made up in demineralised water.

The effects on foliage and habit

In Rose Harrison the first symptoms appeared as interveinal chlorosis confined to the edges of the middle leaves. These were followed by a general reduction in vigour indicated by weaker stems and some loss of colour these signs being most pronounced in leaves at the tops of the plants. A few leaves showed a netting effect and chocolate coloured spots. Later the middle leaves curl downwards at the edges and tips in a characteristic manner. Concurrently these leaves show an interveinal chlorosis and eventually reddish brown areas develop within the chlorotic parts. These soon dry out.

In Monument pronounced interveinal chlorosis occurred on the middle leaves at the same time as on Rose Harrison. This condition continued to be the only symptom for some time. Eventually, however, it spread rapidly up the plants but in contrast to Rose Harrison the leaves remained perfectly flat to the end of the season. There was no effect on the general growth of this variety. Shortly before the blooms were open characteristic chlorosis and netting developed in the uppermost leaves.

Autocrat is interesting in that although reactions to boron deficiency are indistinguishable from those of Monument the two varieties react very differently to omission of manganese. In Autocrat the absence of manganese causes interveinal chlorosis on the middle leaves and this spreads rapidly upwards and the chlorotic areas darken quite quickly. There was none of the fine mottling on the upper leaves. In addition there is a serious reduction in the rate of growth and in the vigour of the plants generally.

In Sussex Bronze the only symptoms observed consisted of some interveinal yellowing on the middle leaves. Sussex Pink, on the other hand, as last year, followed closely the pattern described for Rose Harrison.

The effect on blooms

In Sussex Pink the size and colour of blooms were least affected. In the others flowering was delayed and size, colour and quality of bloom were all reduced. In Monument some flower buds were allowed to develop early. These were all carried on very short stems and buds were distorted irrespective of treatment. In the no-manganese series bud development ceased at an early stage so that none of them had opened up to the time the plants were finally discarded.

The omission of potash

Where potash is omitted in the early life of the plant growth is very seriously affected in all varieties. An interesting feature is the pronounced tendency to produce basal cuttings even when the plants are comparatively small. Another noticeable effect is the exceedingly poor root development under these conditions. Slight marginal chlorosis occurs but the chlorotic areas become brown and develop into marginal scorch so quickly that they are liable to be overlooked. Internodes are shortened and the older leaves die comparatively quickly.

Where potash is withheld later in the life of the plant none of the foregoing symptoms appear to an appreciable extent. Growth generally is retarded, however, so that the plants become stunted and the leaves are smaller. The actual quality and colour of the blooms is not seriously affected but the size is reduced.

In Market Gold the tendency of shoots to spread reported last year was confirmed. The same tendency was observed in Autocrat. Where this variety was deprived of potash in the early stages growth ceased quite soon and some of the shoots collapsed when immature flower buds opened. Where the deficiency operates later symptoms are different in that the effect is mainly one of reduction in growth. It was characteristic of this variety that when the ray florets showed colour regular marginal scorch occurred on the upper leaves.

In Imperial Pink early omission of potash was more effective than on any other variety. In the case of one plant the growing point died completely. Later omission on this variety and on Sussex Bronze caused irregular effects on the foliage. Chlorosis on the upper foliage is entirely interveinal and there was no tendency for the shoots to spread. The effects on growth generally were slight.

Summary

In general it appears that the reaction to an acute boron deficiency is most pronounced in white varieties. To a less degree it also seems that incurved varieties are more susceptible than reflexed. Consequently the most acute effects are produced in white incurved varieties. In this connection Rose Harrison is anomalous.

Acute manganese deficiency is associated with interveinal yellowing on the middle leaves followed, on some of the more susceptible varieties by the netting effect on the upper foliage. This netting is often found in other species suffering from this disorder.

A deficiency which is likely to occur in practice is that of potash. If this operates in the early stages of growth it is clear that profound effects on growth will follow. A deficiency of this nutrient later on does not appear to be so important.

Grateful acknowledgement are made to Mr. C. J. Horwood and Mr. J. B. Stevenson who provided some of the stock used in these experiments.

4. LIME-INDUCED MANGANESE DEFICIENCY IN GLASSHOUSE ROSES

By D. M. MASSEY and O. OWEN

A chlorosis of glasshouse roses has occurred sporadically for some years. It does not appear to have persisted for any length of time nor has it always reappeared in the same places on individual nurseries. In one case within our knowledge a complete house was seriously affected during the whole of one year, yet the following year all the trees made normal growth and produced normal foliage. During the past two years however, the incidence of this disorder has become much more pronounced and we have found it in appreciable amount on six different nurseries. Much of it is now attributed to the fact that tomatoes were grown instead of roses during the war.

The chlorosis starts as a loss of colour between the veins. At first interveinal areas are pale green but later these become yellow. Meanwhile the veins, even the finest of them, retain their original green colour so that the leaf as a whole has a characteristic netted appearance. It is not accompanied by necrosis nor is it accompanied by any extensive leaf fall. In general, the size of the complete leaf is reduced. Frequently the condition develops as the leaf grows but later disappears as the flower bud swells and opens. In other cases the condition persists and worsens so that the flower stems become weak and the blooms are of little value. In one such case growth was so weak that comparatively young trees were dug up and discarded. The distribution of chlorotic trees is erratic. On some nurseries whole houses are more or less affected. On others, parts of houses only show the condition and in others there appear to be continuous areas extending over parts of two or even three houses in a block. The evidence concerning susceptibility of varieties is somewhat conflicting and a variety which is seriously affected on one nursery has been known to be quite normal on another.

The symptoms are the same as those described by American workers for manganese deficiency produced in the rose under artificial conditions. We have been unable to find any record that this disorder has occurred under ordinary commercial conditions.

Qualitative tests on normal and chlorotic leaves indicated high calcium and low manganese in the affected leaves thus suggesting a calcium-induced manganese deficiency. The fact that the chlorosis occurs in soils of alkaline reaction and containing free carbonate supported this diagnosis which was confirmed by quantitative examination.

The table below shows the difference in composition of leaves of the variety Roselandia.

Analysis of Rose Leaves—Variety Roselandia

	N%	CaO%	MgO%	P_2O_5%	Fe p.p.m.	Mn p.p.m.
Normal leaves	3·00	2·12	0·91	0·58	365	90
Chlorotic leaves	1·78	4·67	1·04	0·37	297	62

As will be seen the chlorotic leaves contain less nitrogen, phosphate, iron and manganese than do the normal ones, but they contain considerably more calcium. The data suggest that a deficiency of iron, manganese or nitrogen may be operating and that an excessive uptake of calcium is contributory . That the deficiency is one of manganese has been demonstrated by growing seriously affected trees in sand culture. After some time trees receiving a complete nutrient solution made good recovery and produced normal new growth, whereas the trees receiving the same nutrient from which manganese only was omitted continued to show the characteristic chlorosis.

We conclude therefore that it is manganese deficiency and in view of the calcium values shown and of the fact that all the soils in which it has occurred are alkaline the further conclusion is made that the disorder is lime induced.

A number of corrective measures have been tried since the investigation began. Of these can be mentioned:—(1) Application of manganese sulphate to the beds. This was quite ineffective. This was to be expected since the chlorosis is believed to be induced by the excess of lime in the soil. This excess was already depressing the availability of manganese already present and further additions of this element would suffer the same fate.

(2) Leaf and stem injections with dilute solutions of manganese sulphate. These had no effect and it appears that the rose is not a suitable subject for this technique.

(3) Leaf spraying with various strengths up to 0·5 per cent. of manganese sulphate plus either Estol H or sulphonated lorol as wetters. At low concentrations there was no apparent effect. Nearer to and at the maximum concentration an appreciable amount of injury was caused to both foliage and buds.

(4) Treatment which completely corrected the disorder on one nursery consisted of adding flowers of sulphur to the beds. This treatment is commonly used to reduce the alkalinity of soils and so to correct lime-induced deficiencies. In this particular trial sulphur was pricked in the top 4 inches of soil when the trees were dormant and the beds were bare of mulch, trimmings, etc. It is appreciated that some root injury may result from this treatment but it is to be hoped that it will be more than compensated for by the correction of the disorder. During the whole of the following (calendar) year trees on the treated beds remained a typical healthy green and the trees generally were stronger than their untreated neighbours.

Further extensive trials of this treatment are in progress and results will be reported in due course.

Concurrently the rates of disappearance of sulphur in rose soils and the concomitant effect on the pH are being investigated under controlled conditions in laboratory. In one experiment carried out at a temperature of 23·5° C. 0·2 per cent. sulphur mixed with a soil caused the pH to fall from 7·38 to 6·05 in 5 weeks. During that period almost 70 per cent. of the added sulphur had been converted into sulphate. As temperature will have a pronounced effect on the rate of these transformations it is not to be expected that changes will take place so rapidly in a rose bed where the temperature is lower than that at which the laboratory experiments were conducted.

5. UREA-FORMALDEHYDE REACTION PRODUCTS AS NITROGENOUS FERTILIZERS

By G. W. WINSOR

The need for relatively slow acting nitrogenous fertilizers has long been recognised in horticultural practice. At present this need is largely met by the use of natural organic materials such as hoof and horn. The possible use of synthetic nitrogenous compounds to supplement or even replace these natural products has undoubtedly been stimulated by recent American research on urea-formaldehyde compounds[1,2,3].

Urea-formaldehyde compounds of the type here referred to are readily prepared by controlled reaction between urea and formaldehyde in acid solution, the molar ratio of urea to formaldehyde (U/F ratio) being not less than 1. The products are white powders containing some 35 to 40 per cent. of nitrogen, the properties of which can be varied considerably during preparation by control of the U/F ratio and the pH, time and temperature of reaction. Reactions between urea and formaldehyde have long been used in the plastics industry for the production of resins or, with the addition of suitable fillers and catalysts, for moulding powders. In the latter however the U/F ratio is less than 1, and in general these products are decomposed in the soil too slowly for practical purposes.

The objectives to be sought in the quest for suitable synthetic nitrogenous materials include the following:—

(1) Slow and steady decomposition in the soil to meet the needs of long season crops.
(2) Low initial solubility in water to avoid losses by leaching.
(3) Absence of toxicity to soil organisms.
(4) High degree of "availability" in the soil.
(5) Good physical condition.
(6) Minimum cost per unit nitrogen.

Research on the possibilities of urea-formaldehyde products as nitrogenous fertilisers is as yet far from complete. It is however instructive to see how far the known properties of the products satisfy the aims previously tabulated in this brief survey. It is established that the rate of decomposition of the

materials in soil can be varied within wide limits by suitable conditions of preparation, and it has been claimed that the nutritional requirements of long season crops can be met in this way.[3] Nitrification experiments with samples so far prepared in these laboratories however suggest that the percentage of the total nitrogen which is slowly available is relatively small in relation to the nitrogen rapidly transformed in the early stages of decomposition. Low solubility of the products in water can readily be obtained at low U/F ratios. Urea-formaldehyde preparations do not inhibit the activities of soil organisms, and no free formaldehyde could be detected in extracts of treated soils.[2] The carbon/nitrogen ratio of the products is low, being less than 1 as compared with values of about 3 for natural organics such as hoof and horn. This low C/N ratio indicates that a high proportion of the nitrogen transformed by micro-organisms in the soil should be available for plant growth. Urea-formaldehyde compounds can in fact be prepared which show a high maximum percentage transformation to nitrate in the soil. We have however encountered some difficulty in combining this high availability with relatively low rates of decomposition in the soil. The physical state of the products is excellent; indeed their ability to absorb a high percentage of moisture without loss of their free flowing qualities suggests their possible use not only as nitrogenous fertilizers but also as conditioning agents in mixed fertilizers.[3]

It is concluded that urea-formaldehyde products offer considerable promise as synthetic nitrogenous fertilizers. Investigation of their preparation and properties is proceeding, though they are not yet commercially available. An American Patent granted in 1947[4] outlined a scheme for continuous flow plant production, and the laboratory products have been prepared in considerable quantities at the Bureau of Plant Industry, Beltsville, U.S.A., for crop trials there and at other centres. In this country reference to urea-formaldehyde products is made in the Rothamsted Annual Report for 1949. We have in these laboratories prepared and tested a wide range of urea-formaldehyde materials, and the work will be extended to glasshouse trials if the results show sufficient promise.

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V. GROWERS NOTES

E. R. SPEYER and W. J. PARR.

Gladiolus Thrips (Taeniothrips simplex mor.)

The Gladiolus Thrips, recently recorded for the first time in England (and, indeed, in Europe) is a dark reddish-brown insect (Plate III), about one twenty-fifth part of an inch in length. This particular species bears a close general resemblance to another, *Taeniothrips atratus* Hal., which is often abundant in flowers of many wild and cultivated plants during summer, and which causes injury to flowers of border carnations and petunia in gardens: the latter insect also occurs in flowers of Gladiolus, but causes little if any injury, and does not appear to breed upon the plant.

Specimens of "Thrips" were collected in Hertfordshire and north of England gardens, during July and August, from Gladiolus flowers, the petals of which at most showed hardly perceptible feeding-marks made by the insects: they were referable to 10 different indigenous British species, four of which are known to be injurious to other kinds of plants. The adult insects had merely assembled in the flowers in order to feed upon the pollen and nectar.

The true Gladiolus Thrips, on the other hand, causes extensive "silvering" of the foliage and petals of opening flowers, and in cases of severe infestation the petals fail to develop within the flower-sheaths (Plate IV). Such symptoms afford practically conclusive evidence that this particular species is breeding upon the plants.

The insect was first recorded as a serious pest of Gladiolus in North America in the year 1929, and subsequently became established in Hawaii, South Africa, and Australia. This wide distribution is more likely to have been brought about through transportation of infested corms, upon which the insect lives and breeds under favourable conditions of temperature during the period of storage, than by its own apparently limited powers of dispersal.

All available evidence points to the insect having been imported into England upon corms obtained from the continent of Europe. Since this "Thrips" appears to be unable to survive the winter out-of-doors in colder climates, previous infestations have evidently been of short duration and therefore have not been put on record. The recent series of mild winters in England has doubtless facilitated its survival on corms in storage, and warm springs may have enabled infestations to assume considerable proportions by the time at which the flower-spikes have been formed.

On July 27th, 1950, plants upon a small nursery at Edmonton, Middlesex, were found to be severely infested, and shortly afterwards the presence of the insect upon nurseries in Berkshire, Gloucestershire and Lincolnshire was established.

Habits and life-history

Much attention has been paid to the insect in U.S.A. and the following account is based largely upon the published work of American authors, particularly that of Herr (1934), supplemented by observations made upon the market-garden at Edmonton in July and again in September.

The adults are normally very active when disturbed, but may become sluggish at higher temperatures if exposed for long to sunlight. For the most part, they live concealed within the doubled-over young leaves, within the flower sheaths, and amongst the petals of opening flowers. In autumn they descend below the soil-surface and will continue to feed and breed upon the corms while they are in storage throughout the winter months provided that they are not subjected to temperatures below about 50° F. for any length of time: in temperate or cold climates they do not appear to be able to survive the winter either upon plants or in the soil.

Unmated females will lay viable eggs, and their progeny all develop to adults of the male sex: the latter mate with their parents which then produce offspring of both sexes, with a strong tendency for the females to outnumber the males. In this manner an infestation may be started by a single unmated female. The eggs are inserted, one by one, into the tissues of young leaves, into the inner surfaces of flower-sheaths, probably less often into the petals of opening flowers, and during winter into the more succulent tissues of the corms. The yellow larvae, during the first two instars feed, often gregariously, upon the leaves and flower petals, which assume a silvery appearance, due to the extraction by suction of the cell contents, including chlorophyll and colouring matter, and subsequent entry of air into the plant tissues (Plate IV): flowers also become deformed or fail to expand their petals.

The period of feeding extends over 7 to 12 days in summer. In the 3rd and 4th instars ("prepupae" and "pupae"), during which they neither feed at all nor move about to any extent, the nymphs are secreted usually beneath inturned edges towards the tips of the leaves, or between overlapping leaves, but it is probable that many 2nd instar larvae descend to the ground and complete their metamorphosis beneath the soil-surface.

During warm weather a generation is likely to be completed in about 14 days, so that a severe infestation may arise already at the time at which the early-flowering varieties are forming the flower-spikes.

Control Measures

After the pest has made its appearance upon Gladiolus, it is obviously one which is liable to cause very severe losses to the commercial grower. Concealed, as the insect is, between the unexpanded leaf-blades and within the flower sheaths, chances of bringing an infestation under immediate control are slight.

To growing plants showing characteristic symptoms of injury, application of powders containing BHC would, on account of their fumigant action, appear to be more effective in destroying the insects than sprays containing this compound or dusts and sprays containing DDT. In North America infestations have been rapidly brought under control by applications of powder containing 0·5 per cent. to 1·0 per cent. γ—isomer of BHC.

Riddance of the pest from nurseries and gardens ultimately depends upon the corms being kept in storage at a temperature not exceeding 50° F., with the additional precaution of sprinkling white-flake naphthalene at the rate of about 1 ounce (but not more) to 100 corms or 1 lb. to the bushel. The latter treatment will not cause injury to them during the earlier period of their storage, and will destroy, in the course of 3—5 weeks, adult insects which might otherwise survive at still lower temperatures.

The authors are greatly indebted to Mr. E. S. Skillman (N.A.A.S) for loan of the plate portraying injury to the leaves and unopened flowers of Gladiolus on the left of Plate IV.

REFERENCE

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APPENDIX "B"

MANURIAL TREATMENT IN TOMATO EXPERIMENTS

(Except plots in Appendix C)

			BASE TREATMENT						TOP DRESSING							
House	Plot	Sterilisation	Lime	Stable Manure	Hoof and Horn	Bone Meal	Sulphate of Potash	Sulphate of Ammonia	Sulphate of Potash with first Watering	Balanced Mixture	Dried Blood Mixture	Sulphate of Ammonia	Superphosphate	Sulphate of Potash	Dried Blood	Nutrient Feeding by Solufeeder
1		Formaldehyde	1 ton per acre	15 tons per acre	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre		5 cwts. per acre	6 applications	None					
3	1	Formaldehyde	1 ton per acre	15 tons per acre	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre		5 cwts. per acre	6 applications						
	2	,,	,,		,,	,,	,,		,,	,,						
	3	,,	,		,,	,,	,,		,,	,,						
	4	,,	,,		,,	,,	,,		,,	,,						
	5	,,	,,		,,	,,	,,		,,	,,						
	6	,,	,,		,,	,,	,,		,,	,,						
	7	,,	,,		,,	,,	,,		,,	,,						
	8	,,	,,		,,	,,	,,		,,	,,						
4	4	Steam per acre	1 ton	None	None	None	10 cwts. per acre		5 cwts. per acre	6 applications	None					
	5	,,	,,	,,			,,		,,	,,	,,					
	6	,,	,,	,,			,,		,,	,,	,,					
	7	,,	,,	,,			,,		,,	,,	,,					
	8	,,	,,	,,			,,		,,	,,	,,					
5	1	Steam	1 ton per acre	None	None	None	10 cwts. per acre		5 cwts. per acre	6 applications	1 application					
	2	,,	,,				,,		,,	,,	,,					
	3	,,	None				,,		,,	,,	,,					
	4	,,	,,				,,		,,	,,	,,					
	5	,,	,,				,,		,,	,,	,,					
	6	,,	,,				,,		,,	,,	,,					
	7	,,	1 ton per acre				,,		,,	,,	,,					
	8	,,	,,				,,		,,	,,	,,					
7	–	Steam	1 ton per acre	None	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre		5 cwts. per acre	7 applications						
8	1	Steam	1 ton per acre	None	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre		5 cwts.	None	None					
	4	,,	,,	,,	,,	,,	,,		,,	,,	,,					
	6	,,	,,	,,	,,	,,	,,		,,	,,	,,					
	7	,,	,,	,,	,,	,,	,,		,,	,,	,,					
	2	Chloropicrin	,,	,,	,,	,	,,		,,	6 applications	,,					
	3	,,	,,	,,	,,	,,	,,		,,	,,	,,					
	5	,,	,,	,,	,,	,,	,,		,,	,,	,,					
	8	,,	,,	,,	,,	,,	,,		,,	,,	,,					
9	1	Steam	1 ton per acre	None	None	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre	5 cwts. per acre	None	None					
	2	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,					
	3	,,	,,	,,	10 cwts. per acre	,,	,,	None	,,	6 applications	,,					
	4	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,					
10		Steam	1 ton per acre	None	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre	None	5 cwts. per acre	7 applications	1 application					
11	1	Steam	1 ton per acre	None	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre	None	5 cwts. per acre	6 applications						
	2	,,	,,	,,	,,	,,	,,	,,	,,	,,						
	3	,,	None	,,	,,	,,	,,	,,	,,	,,						
	4	,,	,,	,,	,,	,,	,,	,,	,,	,,						
12	1	Steam	1 ton per acre	None	10 cwts. per acre	None	10 cwts. per acre	None	5 cwts. per acre	None	2½ cwts. per acre		None	2½ cwts. per acre		
	2	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,		,,	,,		
	3	,,	None	,,	,,	,,	,,	,,	,,	,,	,,		,,	,,		
	4	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,		,,	,,		
Rose House		Formaldehyde	1 ton per acre	15 tons per acre	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre	10 cwts. per acre	5 cwts. per acre	7 applications						

APPENDIX "C"

MANURES APPLIED IN PLOTS 1–3 AND 8–10 IN TOMATO HOUSE 4

Plot	Title	Base Manure in Lbs. per sq. yds.				*Top Dressing in Lbs. per sq. yds.		
		Lime	Stable Manure	Super-phos-phate	Sulphate of Potash	Super-phos-phate	Sulphate of Ammonia	Sulphate of Potash
1	Complete Artificials (I) less Nitrogen	1·0	—	0·4	0·1	0·5	—	0·2
2	Unmanured	—	—	—	—	—	—	—
3	Complete Artificials	1·0	—	0·4	0·1	0·5	0·2	0·2
8	Complete Artificials with Dung	1·0	7	0·4	0·1	0·5	0·2	0·2
9	Complete Artificials less Phosphate	1·0	—	—	0·1	—	0·2	0·2
10	Complete Artificials less Potash	1·0	—	0·4	—	0·5	0·2	—

* The Top-dressing was applied in eight equal instalments.

APPENDIX "D"

DATES OF CULTURAL OPERATIONS, 1949-1950

Crop	Sown	Potted into 60's	Potted into 32's	Planted out in Borders	First top Dressing	First Fruit Picked	Last Feed Applied	Last Fruit Picked
Tomatoes	Dec. 15, 1949	Jan. 10	—	Feb. 23	May 4	May 15	Aug. 31	Nov. 11
Cucumbers	Feb. 2, 1950	—	Feb. 16	Mar. 14	Apr. 28	Apr. 7	Sept. 12	Oct. 10

APPENDIX "E"

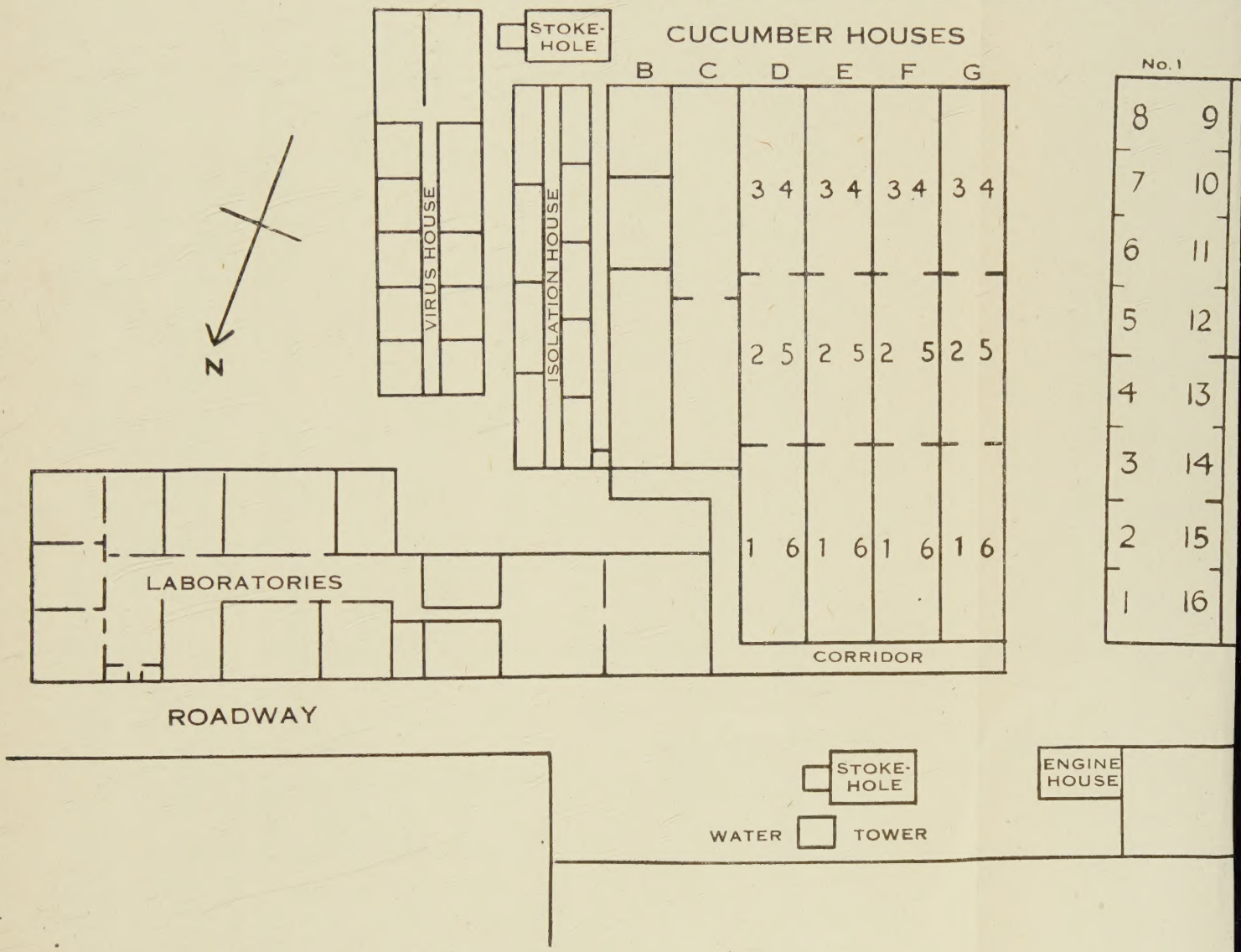
METEOROLOGICAL RECORDS, 1950

Month	Air Temperatures									Rainfall				Mean Soil Temperatures at 9 h. G.M.T.		Hygrometer				No. of Days Fog at 9 h. G.M.T. †	Bright Sunshine	
	Mean		Absolute Maximum		Absolute Minimum		No. of Ground Frosts *	Absolute Grass Min.		Total ppt.	No. of days ppt.	Greatest Fall				Dry Bulb	Depres. of Wet Bulb	Relative Hum'ity	Dew Point		Total Hours	Daily Av'ge
	Max.	Min.	Temp.	Date	Temp.	Date		Temp.	Date			Amt.	Date	4 ins.	8 ins.							
	°F.	°F.	°F.		°F.			°F.		Ins.		Ins.		°F.	°F.	°F.	°F.	%	°F.			
JANUARY	—	34·8	—	—	20	26th	14	15	26th, 30th	·72	9	·27	3rd	39·0	40·5	39·6	1·2	88·9	36·3	6	37·3	1·2
FEBRUARY ...	50·9	37·2	62	17th	22	28th	9	18	28th	3·32	19	·57	2nd	39·7	40·8	42·9	1·7	85·2	38·8	6	58·8	2·1
MARCH	55·1	38·6	65	8th	22	1st	11	15	1st	·74	10	·12	17th	42·8	43·8	46·2	2·9	78·2	38·3	6	120·0	3·9
APRIL	55·1	39·2	66	21st	29	16th	10	20	16th	1·67	19	·33	17th	45·0	45·7	47·8	4·2	69·5	38·0	0	151·2	5·0
MAY	62·4	44·7	73	12th, 21st, 30th	34	5th	5	25	5th	1·42	11	·23	5th, 19th, 25th	53·4	53·0	54·3	3·6	74·1	45·9	0	156·8	5·1
JUNE...	73·6	52·9	89	7th	43	16th	0	32	24th	1·33	8	·39	14th, 22nd	64·1	60·8	65·5	6·4	67·8	54·3	0	244·2	8·1
JULY	70·7	53·8	85	9th	46	15th	0	36	15th	3.33	18	·66	3rd	63·3	62·9	64·2	5·5	72·4	54·5	2	179·8	5·8
AUGUST	71·3	52·3	80	6th, 7th, 22nd	44	28th	0	34	28th	2·03	20	·29	1st	61·1	61·1	63·8	5·2	74·1	55·2	0	154·8	5·0
SEPTEMBER ...	63·8	48·2	71	1st, 4th, 10th, 28th	39	27th	1	30	27th	2·67	23	·24	11th, 15th	55·1	56·2	57·2	3·4	78·8	50·5	2	105·2	3·5
OCTOBER	57·8	42·2	73	5th	23	28th	11	16	28th	·29	5	·14	30th	47·7	49·9	50·5	2·6	81·8	45·0	4	99·4	3·2
NOVEMBER ...	48·7	37·7	57	28th	25	26th	14	20	26th, 27th	4·86	22	1·11	20th	41·9	43·5	43·6	1·5	88·9	40·4	8	46·6	1.6
DECEMBER ...	38·5	30·3	51	1st	19	5th	24	8	5th	1·45	12	·38	1st	34·8	36·6	34·5	1·0	89·5	31·7	6	32·3	1·0
Total							99			23·83	176									40	1386·4	

*Grass min. 30·4°F. or less.

† Visibility 440 yards or less.

DIAGRAM SHEWING ARRANGEMENT



OF EXPERIMENTAL PLOTS, 1950

TOMATO HOUSES